The Blast Furnace and Steel Plant

Vol. XI PITTSBURGH, PA., OCTOBER, 1923 No. 10

Fifth Annual Convention
AMERICAN SOCIETY FOR STEEL TREATING
Pittsburgh, October 8-12, 1923

MONDAY, OCTOBER 8

Morning Session

Meeting in Ball Room, Wm. Penn Hotel
W. J. Merten, Chairman

10:00—Address of Welcome—J. A. Trautman, Jr.
Welcome to Pittsburgh—Mayor Wm. A. Magee.
Response—President T. D. Lynch.

Technical Session

"The Manufacture of Automobile Leaf Springs," C. G. Shontz, Metallurgist, Perfection Spring Company, Cleveland.

"Metallography and Testing of Oxyacetylene Welds," J. R. Dawson, Research Metallurgist, Union Carbide & Carbon Research Laboratories, Inc., Long Island City, N. Y.

"Some Observations on Furnaces and Fuels, Including the Electric Furnace for Heat Treating," E. F. Collins, Consulting Engineer, General Electric Company, Schenecady, N. Y.

"The Tempering of Tool Steel," J. P. Gill and L. D. Bowman, Metallurgists, Vanadium Alloys Steel Company, Latrobe, Pa.

"Abnormal Grain Growth in Cold Rolled Low Carbon Steel," V. E. Hillman and F. L. Coonan, Metallurgist and Assistant Metallurgist, Crompton & Knowles Loom Works, Worcester, Mass. (To be presented by title.)

Afternoon Session

1:00—Exposition opens.
3:30—Technical Session, Motor Square Garden.

"The Annealing of Sheet Steel," Francis G. White, Metallurgical Engineer, National Enameling & Stamping Company, Granite City, Ill.

"Sheet Steel for Automotive Purposes," Harry Martin, Metallurgical Department, Dodge Brothers, Detroit.

"The Manufacture of Sheet Steel," J. H. Nead, Research Metallurgist, American Rolling Mills Company, Middletown, Ohio.

"Sheet Steel Specifications," H. M. Williams, Metallurgist, General Motors Research Corporation, Dayton, Ohio.

Evening Session

Exposition Open until 10 P. M.

7:00—Moving pictures.

TUESDAY, OCTOBER 9

Morning Session

Meeting in Ball Room, Wm. Penn Hotel

9:30—Technical Session.

"Measurement of Carbon Penetration in Carburized Steels," S. P. Rockwell, Consulting Metallurgist, Hartford, Conn., and Frederick Downs, Chemist, New Britain Machine Company, New Britain, Conn.

"Case Hardening and Other Heat Treatments as Applied to Gray Cast Iron," H. B. Knowlton, Instructor, Milwaukee Continuation School, Milwaukee, Wis.

"The Influence of Barium Carbonate upon Wood Charcoal Used for Cementation," B. F. Shepard, Metallurgical Department, Ingersoll-Rand Company, Phillipsburg, N. J.

"Protective Coatings for Selective Carburization," J. S. Vanick and H. K. Herschman, Metallurgist and Assistant Physicist, Bureau of Standards, Washington.

"Investigation of the Treatment of Steel for Permanent Magnets," R. L. Dowdell, Instructor in Metallurgy, University of Minnesota, Minneapolis, Minn.

"The Thermal Treatment of the Light Alloys of Aluminum and Copper," A. M. Portevin and Prof. H. L. LeChatelier, Paris, France. (To be presented by title.)

Afternoon Session

12:10—Plant Visitation, Westinghouse Electric & Mfg. Company.
1:00—Exposition opens.
3:30—Round Table Discussion under direction of Standards Committee, Motor Square Garden. R. M. Bird, Chairman.

Evening Session

Exposition Open until 10 P. M.

7:00—Moving pictures.
9:30—Annual Smoker and Entertainment, Ball Room, Wm. Penn.

WEDNESDAY, OCTOBER 10

Morning Session

Annual Meeting of the Society, Ball Room, Wm. Penn Hotel
T. D. Lynch, Chairman

9:30—Report of Tellers of Election—C. G. Shontz.
President's Address—T. D. Lynch.
Report of Treasurer—J. V. Emmons.
Report of Secretary—W. H. Eisenman.
Report of National Committees:
Standards—R. M. Bird.
Constitutions and By-Laws—S. M. Havens.
Report of Chapter Delegates.

Afternoon Session

1:00—Exposition opens.
2:00—Plant Visitation, Homestead Works, Carnegie Steel Company.
3:30—Round Table Discussion and Technical Session on Heavy Forgings, Motor Square Garden.

"The Manufacture of Heavy Forgings," W. R. Klinkicht, foreman, Heat Treating Department, Pollak Steel Company, Cincinnati.

"Determining Heat Treating Costs," H. F. Wood, Metallurgist, Wyman-Gordon Company, Ingalls-Shepard Division, Harvey, Ill.

"Spark Testing of Steel," Don Stacks, Consulting Metallurgical Engineer, Hartford, Conn.

"Some Fundamental Defects of Hardened Steels," Dr. Leslie Aitchison, Birmingham, England. (To be presented by title.)

Evening Session

Exposition Open until 10:00 P. M.

7:00—Moving pictures.
9:30—Informal Dance, Ball Room, Wm. Penn Hotel.

THURSDAY, OCTOBER 11

Exposition Opens at 10:00 A. M.

9:30—Technical Session, Ball Room, Wm. Penn Hotel. H. M. Boylston, Chairman.

"Effect of Heat Treatment on Lathe Tool Performance and Some Other Properties of High Speed Steels," H. J. French, Physicist, Bureau of Standards, Washington; Jerome Strauss, Materials Engineer, U. S. Naval Gun Factory, Washington, and T. G. Digges, Assistant Physicist, Bureau of Standards, Washington.

"Secondary Hardness in Austenitized High Chromium Steels," E. C. Bain, Research Metallurgist, Atlas Steel Corporation, Dunkirk, N. Y.

"The Hardening of Steel," Zay Jeffries and R. S. Archer, Research Bureau, Aluminum Company of America, Cleveland.

"Crystallization of Iron and Its Alloys," Albert Sauveur, Professor of Metallurgy, Harvard University, Cambridge, Mass.

"X-Ray Examinations of Steel Castings," F. C. Langenburg, Metallurgist, Watertown Arsenal, Watertown, Mass.

Afternoon Session

2:30—Technical Session, Motor Square Garden. Hardness Testing Symposium, National Research Council. Maj. A. B. Bellis, chairman.

"The Hardness of 'Common High' Sheet Brass," A. L. Davis, Metallurgist, Scoville Mfg. Company, Waterbury, Conn.

"Magnetic Indications of Hardness and Brittleness," A. V. de Forest, Research Department, American Chain Company, Bridgeport, Conn.

"Testing of Steel for Hardness," H. M. German, Metallurgist, Henry Disston & Sons, Inc., Philadelphia.

5:30—Exposition closes.

Evening Session

6:30—Annual Banquet of the American Society for Steel Treating, English Room, Fort Pitt Hotel. Tickets at Registration Desk.

FRIDAY, OCTOBER 12

Morning Session

Exposition Opens at 10:00 A. M.

9:30—Technical Session, Ball Room, Wm. Penn Hotel. Paul D. Merica, chairman.

"Salt Baths and Containers," Sam Tour, Metallurgist, Doehler Die Castings Company, Brooklyn, N. Y.

"The Physical Properties of Metals at Elevated Temperatures," Vincent T. Malcolm, Metallurgist, Chapman Valve Mfg. Company, Indian Orchard, Mass.

"The Ageing of Steel," W. P. Wood, Department of Metallurgy, University of Michigan, Ann Arbor, Mich.

"Conical Illumination of Metallography," H. S. George, Union Carbide & Carbon Research Laboratories, Inc., Long Island City, N. Y.

"Carbon and Carbo-Vanadium Steel Castings—A Comparison," J. M. Lessells, Metallurgist Engineer, Westinghouse Electric & Manufacturing Company, East Pittsburgh.

"The Theory of Quenching in Steels," Kotaro Honda, Tohoku Imperial University, Sendai, Japan. (To be presented by title.)

Afternoon Session

1:00—Plant Visitation, National Tube Works, McKeesport, Pa.
2:30—Symposium on Metallurgical Education, Motor Square Garden. Prof. S. L. Goodale, chairman.

Evening Session

7:00—Band concert.
10:00—Exposition officially closes.

Pittsburgh as a Tonnage Producing Center*

Concentration of Mass Production a Vital Point in Pittsburgh's Supremacy—Proximity of High Quality Fuel and Excellent Transportation Facilities a Factor

By F. J. CROLIUS

PITTSBURGH has not yet relinquished her position as central of the steel industry. As we enumerate the new mills contemplated elswhere, estimated and ultimately constructed and put in operation, as we visualize the new districts which spring up and expand, adding their quota to the enormous ouput of steel in its myriad of useful forms and shapes,—we might be led to believe that Pittsburgh was falling behind in the race. But she is not. Pittsburgh's position as a *tonnage producer* is still unquestioned. This supremacy is not a matter of sentiment,—it is a matter of fact,—based on capacity to produce, a finely organized mechanism for assembly, production and distribution,—banking facilities, bred in the atmosphere and a body of workmen proficient in the art of heavy tonnages.

Nowhere else will you find a grouping of coal fields, intimately connected with the most modern by-product coke-ovens of capacity enormous enough to serve 30 or more 500-ton blast furnaces; blast furnaces tapping their iron into *hot metal cars* for quick transfer to adjacent open-hearth furnaces great enough in capacity to convert all this and more into ingots which are rolled into miles of finished steel together with a diversification of rolling capacity in unmatched concentration. But more important than even the *hot metal* feature is the consolidation of power, which here is developed to an extent equal to a great central station; this power,—a recovery from blast furnace gases, coke-breezes from by-product ovens, and blast furnace screens,—and from waste-heats of the open-hearth, fired with gas and tar from the by-product ovens and exhaust steam from mill engines,—is massed into a great super-power system which energizes the motored activities throughout these steel processes and transformations.

It might be well to remark that "heavy tonnage" production is a vasty different conception than "light tonnage."

Heavy tonnage involves the handling and rehandling of many times the aggregate tonnage of raw materials,—in process,—semi-finished, finished and waste or dross, —while "light tonnage" is largely a question of rehandling 25 per cent scrap or whatever percentage is a resultant of the particular operation. As an illustration, a single ton of metal produced from the ore to the finished plate or rail or structural shape or bar requires the movement of not far from 200 tons of ore, stone, coal, coke, iron, scrap, ingots, slabs, blast, waste gases, water and steam. This total seems incredible, but it is a fact. While the "light tonnage" product usually involves less than a quarter of such total.

One of the serious items in any industry is the cost of handling raw materials, partly finished, and finished products.

The *handling* of materials is purely *non-productive,*—unpaid effort,—no amount of trucking, piling, loading, unloading, pumping and blowing adds an iota of intrinsic value to an article, but the cost of this non-productive labor must be added into the selling price.

The concern whose handling costs is reduced to a minimum, or whose internal movements are intensively co-ordinated, can produce cheaper.

All of this movement necessitates equipment on a colossal scale and men trained to its constant usage.

Herein Pittsburgh is supreme.

Many districts have sprung up,—but as a district, each is relatively small in its comparative tonnage.

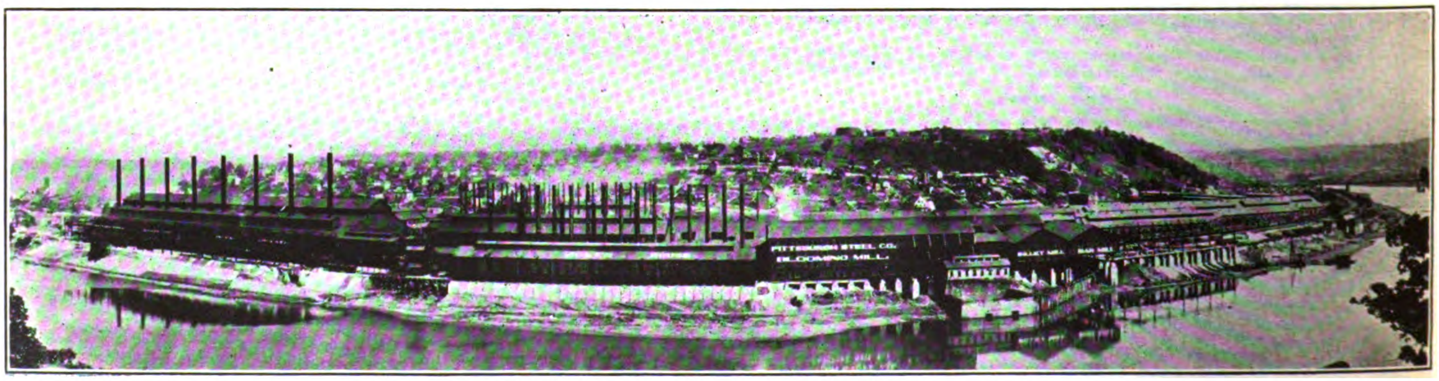
Outside of Chicago and the lake ports,—Wheeling and Portsmouth with the Ohio River; Granite City, Ill., with the Mississippi River, no other district possesses the advantages of water transport,—both for raw material and for finer products.

The importance of water transport may be summarized by an excerpt from U. S. Commerce reports recently published, under title, "The British Steel Industry."

"The Freight Factor.

"Steel districts that have been described in the forgoing paragraphs, except Sheffield and the Midland generally, have that important industrial advantages of *good trading location,* along with such other significant characteristics as have determined their growth around a particular point.

"In those areas the majority of steel plants cluster *at or near means of water transport to the sea.* Even Shef-



Bird's-eye view of one of Pittsburgh's great steel plants located on the upper Monongahela River

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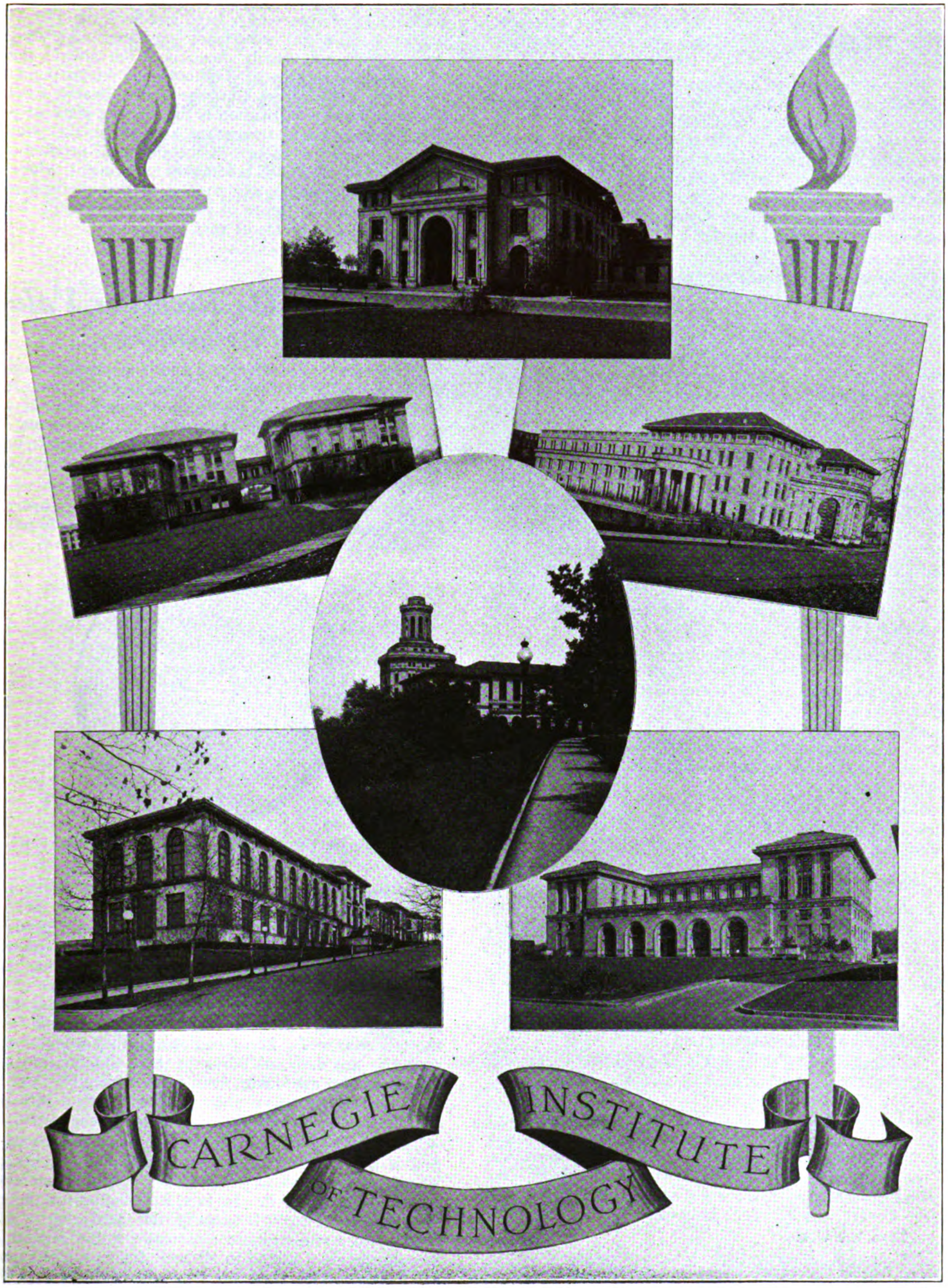

This famous institution is always a center of interest for convention visitors.

field, that noted island focus,—has canal service east and west to the coast, as well as effective railroad connections, which promote short haul traffic.

"There is no need to dwell on the point of locational advantage; it is a recognized and coveted foreign trade facility everwhere. But for Great Britain, so large an exporter of steel products, and so heavy an importer of steel-making raw materials, there is here a keynote of competitive conditions that in itself may more than effect disadvantageous in adequacies of plant, small scale of production, or defect of organization criticized by observers in other countries like the United States, etc."

What is true in England is true in America,—but Pittsburgh does not suffer from "Small scales of production or defects of organization," the reverse of that is her bulwark.

There are 432 blast furnaces in the United States, with a total rated capacity of 49,000,000 tons per year; of these 59 belong to the Carnegie Steel Company alone and 46 are closely grouped in the Pittsburgh district. In addition to the Carnegie group, there are 27 others operated by Jones & Laughlin, American Steel & Wire, National Tube Company and Pittsburgh Steel, and others, mostly single furnace operators. This gives Pittsburgh 86 large and modern blast furnaces with a total production capacity of nearly 15,000,000 tons of iron per year, or about 30 per cent of the total for the entire United States.

It will be noted that the Pittsburgh group of furnaces average nearly 500 tons per day per furnace, while the average for all others falls below 300 tons per day. This is significant of Pittsburgh tonnage.

While the total steel producing capacity in the United States aggregates about 54,000,000 tons annually, more than 13,000,000 tons will be found within the Pittsburgh district, a very impressive 25 per cent. A single plant at Homestead operates 66 large open-hearth furnaces with an annual production well over 2,000,000 tons, leading all Americans producers in the cost per ton of high-grade open-hearth steel.

Most of this "heavy tonnage steel" is rolled to finished forms in Pittsburgh; as a matter of fact, the rolling capacity of Pittsburgh mills is so great that ingots and slabs are often absorbed from nearby districts to maintain production schedules.

Plate, bars and rounds, structual material, rails and track materials, cold rolled shafting, tubes and pipe for boilers, tanks, stacks, etc., are the principal finished shipments, with sheet bar an important semi-finished product for sheets and and tin plate manufacturing. Even this later is delivered to local sheet mills, which specialize in the manufacture of highest grade automobile sheets and corrugated and galvanized sheets.

The McKeesport Tin Plate Co. is the largest individual tin plate plant in the world with an annual capacity of more than 4,000,000 boxes.

Pittsburgh is the center of steel mill engineering and construction companies. Most of the successful mills have been designed and built by Pittsburgh companies. United Engineering Company, Mesta Machine and Maskintosh-Hemphill are names which adorn most successful tonnage mills, not only in this district but throughout the world.

Not less an authority than Alva C. Dinkey, formerly president of the Carnegie Steel Company, now president of the Midvale Company, concludes an analysis of the future of Pittsburgh with the following thought: "In addition to the many widely enumerated advantages, natural and otherwise, which have endowed the Pittsburgh district with world supremacy there remains still another factor, not usually mentioned, but always potent, the Carnegie Institute of Technology. At no point was the vision of Andrew Carnegie more clearly forecast. This now famous institution is the meeting place of practical experience and theoretical knowledge, the point of contact where the science of metallurgical production is blended with the art of laboratory experiment, where the youth of the country are trained in the atmosphere of achievements. The future of Pittsburgh may safely be left in the hands and minds of such boys.

Has the CO-2 Recorder Value

By W. F. SCHAPHORST*

Speak about a CO_2 recorder to the average engineer and he is liable to take on a confused air because he doesn't know what CO_2 means, and feels that he is wading beyond his depth in attempting to converse on such a subject. CO_2 belongs in the realm of chemistry and not in engineering, according to the notions of the average engineer.

However, there is nothing complex about operating a CO_2 machine. The engineer doesn't necessarily have to know anything about chemistry, even though combustion is a chemical process. He needn't even know what the chemical symbol CO_2 means. Continuous records are now made by a reliable machine that works automatically as long as it is in working trim. To keep the machine in order is not a problem of chemistry, but one of mechanics, or perhaps some engineers would prefer to call it "engineering," in which case the engineer will fit into the job very well. Many engineers—thousands of them, perhaps—are daily attending to their CO_2 machines and recorders and are doing their work perfectly. Yet they don't know any more about chemistry than any other average man who has never dabbled in chemistry.

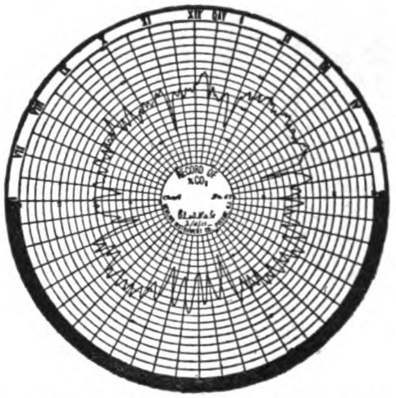

Chart from CO_2 recorder on natural draft chain grate.

If you have a CO_2 recorder in your plant you will find it a good plan to instruct several men in its care. There is no reason why the chief engineer alone should be able to care for it. In fact, it is better for the chief to assign the duty of keeping the analyzing machine a-going to a subordinate and make it his regular job. Should the chief attend to all such details himself he will certainly overlook them on days when he considers other work more important.

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*Mechanical Engineer, Newark, N. J.

First Large Gas-Engine Installation in American Steel Works[*]

Description and Operating Characteristics of Sixteen Blowing-Engine Units of 2,000 hp. Each, Eight Electric-Generating Units of 1,000 hp. Each and Gas-Cleaning Plants

By **E. P. COLEMAN**[†]

PART II.

THE piston is of cast iron, nearly as long as the stroke because of its action as an exhaust valve. Five grooves are provided at each end, equipped with dowels in such manner that the five snap rings are held with their openings near the bottom of the cylinder. The piston resting on the cylinder wall closes the opening through the ring and prevents leakage and possibly premature ignitions. Cooling water is supplied through the hollow rod by means of swinging connections.

The crosshead is of the slipper type babbitt faced. The marine type connecting rods are forked at the crosshead end. Bearings are split shells, babbitt lined for the crank and phosphor bronze for the crossheads, held by bolted caps.

The crankshaft for the 2,000-hp. engine is of the built-up type and is carried by four bearings. Each crank pin is carried by two forged steel webs between its pair of main bearings and to these webs are bolted the counterweights. Each end of the shaft projects beyond its outboard bearing and carries a crank and eccentrics for the gas and air pumps. The shaft for the 1,000-hp. engine is a single forging, being in other respects similar to that for the 2,000-hp. engine. All of the principal forgings were made at the Krupp works in Germany.

The flywheels for the 1,000-hp. engines are 17½ ft. in diameter and weigh 45,000 lb. The wheels for the 2,000-hp. engine are of 20 ft. diameter and weigh 65,000 lb. The wheels were cast in halves, and the fastenings are steel links shrunk into place at the rim and bolts at the hub.

The inlet valves are steel forgings of the mushroom type located in casings at the top of the cylinder heads. They are opened by cams located on a shaft parallel to the axis of the motor cylinder and driven by bevel gears from the crank shaft, and closed by strong helical springs.

Ignition is by means of electric spark of the break or arc type, with two igniter plugs in each cylinder head. The electric current is furnished by magnetos, one for each plug. The current is produced in the following manner: The magneto armature is first slowly rotated in opposition to the force of a spring through an angle of about 30 deg. from its initial position. It is then released and under the action of the spring executes a rapid return motion or oscillation. During this return motion the igniter terminals are mechanically separated and the arc formed, the motion of the armature being transmitted to the plugs through cranks and reach rods for this purpose. The magnetos are now being discarded in favor of a direct-current system of ignition of simple form.

The timing of the ignition is accompanied by means of the igniter shaft connected to the cam shaft through a helically slotted sleeve and a pair of spur gears. By sliding the sleeve along the shaft, the phase of the igniter shaft is advanced or retarded. One of the spur gears is provided with sufficient width of face to accomplish the required range of movement. The sleeve and hub form a triple threaded screw and nut, and have proved very satisfactory in operation. The apparatus is shown in Fig. 20. The equivalent device furnished by the makers consisted of a single spiral slot and feather which proved defective in wearing qualities.

The regulation of the 1,000-hp. units is by a butterfly throttle valve under the control of a Tolle governor. The strength of these governors is about 2,000 lb. The throttle valve is located in the gas supply pipe of each pump, as close as possible to the pump.

The 2,000-hp. engines are regulated by means of bypass valves located at the gas pumps, and under the direct control of an adjustable-speed oil-pressure governor. Each gas pump, in addition to its original distributing valve, is provided with a reciprocating bypass valve, driven from the pump valve-gear. This valve is of the hollow plug type turned to a working fit in its valve cylinder bushing, and is provided with ports through the walls of the hollow plug. Corresponding ports through the walls of the valve cylinder bushing communicate respectively with A, the gas pump discharge passage, and B, the gas pump clearance. Two respective leakage paths are thus formed through which a portion of the gas is bypassed back into the supply pipe of the pump. The hollow plug valve of the bypass is arranged for partial rotation on its axis under control of the governor, and the angular position of the plug valve determines the degree of opening of the bypass ports, which in turn govern the quantity of gas returned to the pump supply pipe. Due to the construction of the main pump valve, bypassing from the passage A can occur only during the suction stroke of the pump, the bypass port being connected to a chamber which communicates with the pump discharge passage only during such suction stroke. The bypass port from the pump clearance allows bypassing to occur during the discharge stroke of the pump.

The governor is of the adjustable-speed oil-pressure type, controlling the valves directly by means

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[*] Presented at the annual meeting, New York City, 1910, of the American Society Mechanical Engineers.

[†] Lackawana Steel Company, Buffalo, N. Y. Member of the A. S. M. E.

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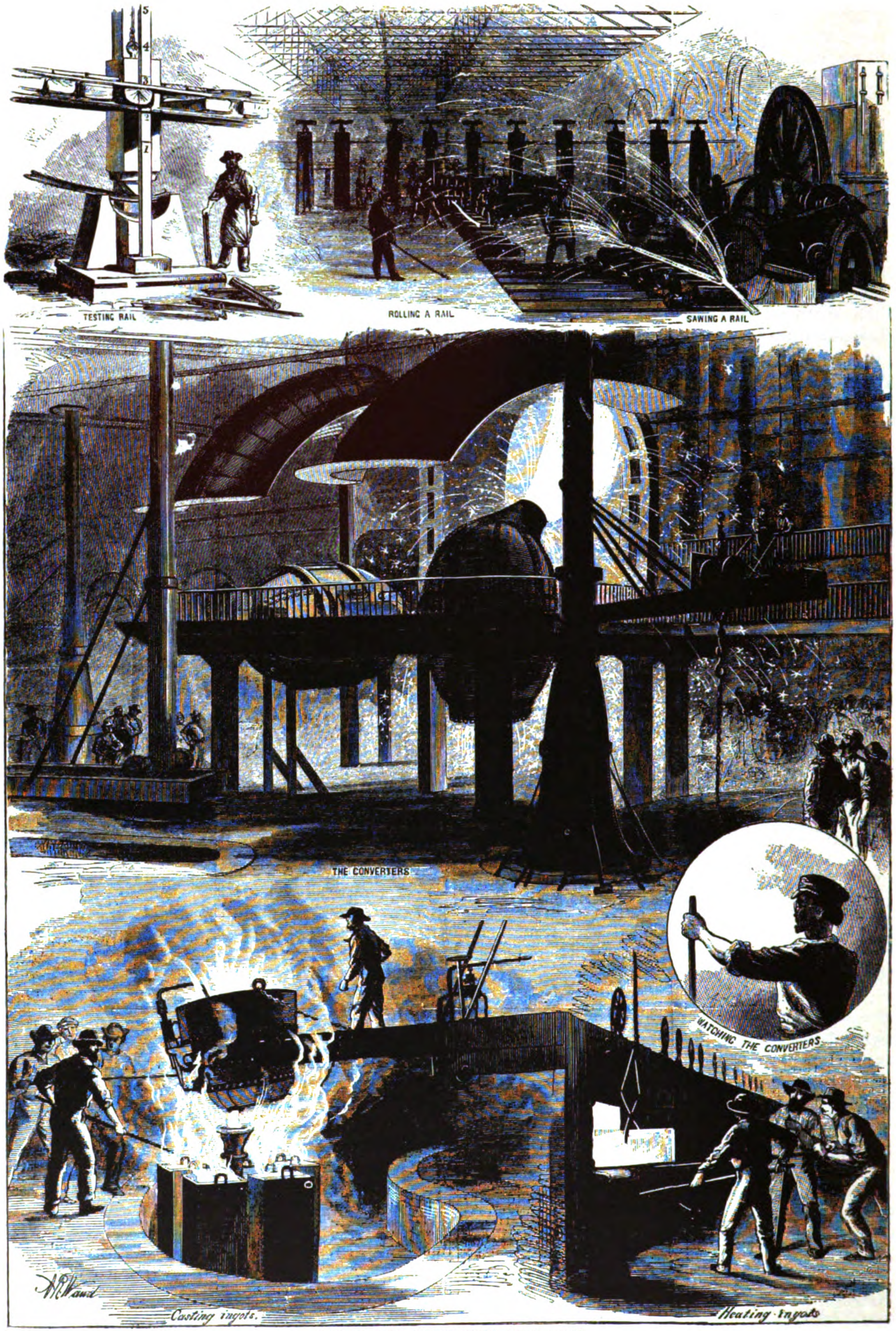
252 HARPER'S WEEKLY. [March 25, 1876.



BESSEMER STEEL MANUFACTURE.—[See Page 253.]

Bethlehem Iron Works
Bethlehem, Pa.

a piston of 4-3/16 in. in diameter operating differentially against the force of a spring. The total tension of the spring is about 830 lb. A 3¾-in. by 3-in. single-acting triplex oil pump is driven by means of a 2-in. Renold silent chain from the cam shaft of the engine. The oil is discharged through a ½-in. orifice of special design, the area of which is controlled by a needle valve. The motion of the small piston is transmitted by levers, shafting, and reach rods, and controls the angular position of the bypass valve. The needle valve is linked to the timing device of the igniter mechanism in such manner that the time element or lag of the igniter is neutralized, the ignition remaining constant at all speeds.

The speed variation between the extremes of travel is 4 per cent. The energy required to drive the pump amounts to about 0.6 hp. The valve gear, governor, and timing device were designed by the author with the assistance of Mr. Hugh Boyd and the entire apparatus was constructed in the shops of the steel company.

The general arrangement of the governor is shown in Fig. 22 and a chart from the Uehling revolution recorder in Fig. 23. The speed depressions recorded in the latter indicate periods of casting and checks at the furnace.

Positive lubrication of the motor cylinders is accomplished by force-feed pumps of the screw-press plunger type. These pumps are driven by lever and rachet, operated by cams located on the engine cam shaft. The oil pump cams are located in such manner that the oil injection occurs during each compression stroke of the motor piston. There are three oil inlets for each end of the motor cylinder, one at the top and one at each side near the bottom. An individual screw plunger serves each oil inlet, which is provided with a check valve.

General Notes Relating to Operation.

Both gas-cleaning apparatus and the gas engines were installed at an early stage in the history of the art and are necessarily imperfect when compared with modern examples to which have been applied those essential refinements that can be gained only through experience. The average dust content of gas as delivered to the second-washed main amounts to about 50 to 80 mg. per cum., equivalent to from 0.022 to 0.035 grains per cu. ft., which would rightly be considered bad practice in modern gas-cleaning plants. It therefore is fortunate that the type of engine selected is able to operate perfectly well when supplied with this imperfectly cleaned gas, without any distress whatever.

Gas leaves the furnace top at a temperature of about 550 deg. F. In summer it enters the fans at about 77 deg. and leaves the fans at about 60 deg. F. The water used in the tower amounts to about 75 gal. per 1,000 cu. ft. of gas. The quantity of waste water used in the fan washers is not accurately known.

The cleaning of the gas at washers Nos. 1 and 2 is less complete than that at washers Nos. 3 to 6. At the two former the dust content in second-washed gas as delivered averages about 0.035 grains per cu. ft.

At gas washers Nos. 3 and 4 the dust content in the gas is about as follows.

Gas	Cooled	First-Washed	Second-Washed
Average grains per cu. ft.	0.328	0.061	0.022
Maximum grains per cu. ft.	0.980	0.100	0.100
Minimum grains per cu. ft.	0.0044	0.0044	0.0044

Dirty plugs are caused by slipping furnaces and wet gas containing dirt which fouls and bakes at the terminals. The plugs require cleaning on an average of once to twice per month. The spherical seat requires regrinding once in two months, and the plug must be retubed once in six months.

Premature combustion is due to high hydrogen content in the gas, sharp edges or corners of metal exposed to the flame, dirt, and improper piston packing. Back-fires are due to prematures during the period of inlet opening, or to leaking inlet valves under usual conditions. The plant under discussion has had but little of any such trouble. Miss-fires are due to wet gas, faulty plugs or magnetos and weak mixtures.

Cylinders, Pistons, Rods, Valves, Etc.

The average life of a motor cylinder is about four or five years, during which time the wear as measured on a diameter is about ⅜ in. The cylinder is then bored out and bushed. There are practically no cylinder failures from any cause other than wear.

Exhaust ports at power house No. 1 become clogged with flue dirt and require cleaning after about three months of operation. Exhaust ports at the blowing-engine houses do not foul at all. The difference is probably due to the cleaner gas at the blowing-engine houses, and possibly in some degree to the precipitation of moisture and dirt in the 96-in. headers.

Cylinder relief valves require cleaning about once a month. Jackets of cylinders and heads are cleaned about once a year.

Cylinders and pistons are inspected only when conditions indicate. Their wear is measured and recorded at the same time. A test for tightness consists in placing the crank on the dead point and subjecting one end of the cylinder to air or exhaust pressure, the plugs being removed from the opposite head to indicate leakage, if any, through the piston.

The 38½-in. pistons have a life of from three to five years. There are but few piston failures due to any cause other than wear. A few have occurred which have been due to the water connections falling down inside the piston and wearing a hole through the bottom. When a piston has worn, say 5/16 in. at the bottom, it is turned over and used in a standard cylinder. There are at present two standard diameters, 38½ in. for new cylinders and 37½ in. for bushed cylinders.

When it becomes necessary to remove the piston rod, the piston is broken away, either with dynamite or under the drop hammer.

The wear of piston rods occurs principally at the end of the stroke and amounts to about a quarter of an inch on the diameter in three years. It is then turned and will suffice for two or three years more.

The average life of the motor cylinder heads is not well established, but it may be set at three years or more. A few of the original heads at the blowing engines are still in service. Failures of these occur principally at the junction of the jacket wall and the main flange on each side of the inlet valve chamber, but this trouble has been substantially eliminated by employing proper fillets. Some heads have developed cracks through the inner wall two or three have had the inner walls blown entirely away, but this was found due to faulty castings.

The inlet valves last about three years before turning and about the same time after they are turned down. They do not require grinding-in except when new. Stems are broken occasionally near the top yoke. Little cleaning of the inlet valve or the ports is necessary.

Gas pump cylinders and heads require cleaning every six to eight months on account of dirt getting into the clearance near the bottom. By feeding a little kerosene into the suction pipe, cleaning of the pump valves is avoided.

Cylinder heads are packed principally with 1/16-in. woven wire insertion asbestos sheet. Piston joints are made up either with 1/32-in. wetted asbestos paper, or with a paste of litharge and glycerine, or with another form of packing known under the trade name of "900."

The life of the 1-7/16-in. snap piston rings is about two years. The openings are securely doweled in place near the bottom of the cylinder, being thus effectively closed by the piston which is always in contact with the bottom of the cylinder.

The piston rods are packed with four cast-iron rings of the Walker type in a casing exterior to the head. Packings are overhauled about every six months to renew broken springs and rings. Casings are trued up at the time of overhauling the piston once in two or three years.

The swinging connections for the piston water supply require to be packed about twice a year. The life of the brass goose necks is about two years.

Rod connections require keying up on the left side once a year and on the right side once in two months. The main bearings have required no adjustments.

The life of the inlet cams is about six years. Wear of the steel gears of the layshaft occurs on four teeth at the end of four or five years; the gears are then shifted on the shaft so that unworn teeth are in action during the inlet valve opening.

The inlet valves are operated through heavy push rods driven by cams and rollers. High inertia stresses are thus developed at the higher engine speeds. With present inlet valve springs which operate under a compression of 2,500 to 3,500 lbs. at the blowing engines, the roller leaves contact with the same at about 65 to 70 rpm. Many of the original push rods have been broken by the resulting inertia stresses and new and stronger rods have been made.

As previously stated the shaft of the 2,000-hp. engine is of the built-up type and it has been the cause of no trouble whatever. There have been, however, several shaft breakages at the 1,000-hp. engines which have shafts forged in one piece and operate at 100 rpm. The author has made no investigation relative to the stresses in these shafts, but believes that their life would have been longer had they been of the built-up type and of present diameters.

At the 1,000-hp. engines there has also been trouble with certain brackets and fastenings due to inertia stresses set up by the inlet gear. Since the governor is driven from the layshaft, considerable wear is imposed on the mechanism due to reversal of the torque at the layshaft as the point of each cam passes under the roller. Some trouble from prematures at the 1,000-hp. engines was experienced, due to the indicator holes through the flange of the cylinder head. Water cooled indicator connections were substituted.

Operating Costs.

The fuel consumption at the blowing engines amounts to about 18,500 Btu. per ihp. hour at the blowing cylinder, equivalent to 162,000,000 Btu. per hp. year of 8,760 hours. This is equivalent to 5.79 long tons of steam coal which has a heating value of 28,000,000 Btu. per ton. Assuming the price of such coal to be $2 per ton, the fuel cost becomes $11.58 per delivered hp. year of 8,760 hours.

Other operating costs at blowing-engine house No. 2 for the year 1907 were as follows. A continuous output of 6,000 hp. at the blowing cylinders was assumed, which is as nearly correct as possible, and on this basis the various costs were itemized.

OPERATING COSTS AT BLOWING-ENGINE
HOUSE No. 2, 1907

	Cost per d.hp. year
Producing labor	$4.504
Labor to repairs and maintenance	0.320
Material to repairs and maintenance	1.152
General	3.962
Total operating cost	$9.94

The total cost of fuel and operation under the conditions assumed is therefore $21.52 per hp. year of 8,760 hours.

Fig. 28 represents the gross mechanical efficiency of the mechanism plotted against the blast pressure. It is the ratio of the sum of pump and compressor horsepowers to the total indicated motor horsepower, and is a measure of the degradation due alone to the mechanical friction of the mechanism. Fig. 29 represents the new mechanical efficiency of the engine, or the ratio of useful work in the blowing cylinder to total indicated work in the motor cylinders and is a measure of the loss due to the sum of pump work and mechanical friction.

The expression net ihp. occurring in the tabulated material from the various engine trials is herewith defined as the difference between the total indicated horsepower of the motor cylinders, and the total indicated horsepower of the pumps. Having in mind the above definition, the curves relating to heat-transforming efficiency, and heat consumption, indicated in Figs. 33 to 35 are self-explanatory.

DISCUSSION

J. Morgan: The development of the steam turbine as an efficient motor of high rotative speed gives to the metallurgical engineer the further development of the turbo-multiple stage blowing engines, first put in operation in 1904 at Middlesboro, England, and now with over 20 similar machines at English, Scotch and Continental works.

There are two such machines blowing furnaces in this country, with several others building. This bids fair to be the furnace blowing engine of the future, which the works' engineer must compare with the present complicated reciprocating blowing engine, whether gas or steam driven.

The advantage of the turbo-blower should prove to be fair over-all economy, small size, cheapness, absence of valve mechanism, lessened repairs, small attendance and other operating costs; in short, its small fixed and operating charges.

There has been some discussion indicating that the gas engine should be put in a dust proof box, one advantage the turbine now has. It is an enclosed mechanism. It is also a hardy mechanism, and its maintenance must be less than that of any reciprocating engine we know of.

With reference to German condition, we must remember that coal is about $2.50 a ton in the Westphalian district and labor and material are cheaper there than here, so that the maintenance costs in Germany are comparatively lower, and consequently heavier running expenses can be tolerated. I have tried to state these facts more definitely, emphasizing at the same time that I do not know much about the costs of repairs of gas engines.

The question of gas installation at works is to be considered from the economic point of view. Mr. Coleman's paper is most valuable in its facts and experiences. It is a message of cheer to the engineer who proposes to install gas engines. There can be nothing worse to come. The history of the work of the Lackawanna engineers is a tribute to their resourcefulness, patience and courage.

It is not certain that the gas engine, in its present condition, has an economical use at any American steel works. They are now a fashion. In the discussion of Mr. Freyn's notable paper* Mr. Maccoun sounds a necessary note of caution that "all the conditions should be studied," and later, "in many cases gas-engine installation may be carried too far."

It seems certain that in the present state of the art the steel works located in the cheap coal districts cannot use gas engines economically. It is a question if any of our steel works are now so located that they can. Colorado, Tennessee and the Pittsburgh districts all have coal nearly at their doors, while Chicago, Gary, Buffalo, Pennsylvania and Bethlehem are in the debatable region.

The items that now enter into the discussion in the order of their importance are, first, the fixed charges; next the fuel cost and then the operating costs and repairs.

If it is proposed to use gas engines for the purpose of economizing in the generation of electrical power for example, we find almost any steel works' plant has a load factor of less than 50 per cent, for the reason that power plants must be built to meet the maximum demand, and when in any such plant, deduction is made for Sundays, holidays and spare engines, there are few working plants that run with a 50 per cent load factor. The Cambria plants run with about 45 per cent, so that 50 per cent or less is about the load under which the cost of production current must be considered.

The relative costs of gas-engine and turbine plants are very nearly two to one. A large modern turbine plant including boilers can be built for about $50 or $55 per kw. capacity, and a gas-engine plant, including the gas-cleaning apparatus, costs about $96 per kw. capacity.

This estimated cost of turbine-generator plant embraces everything from the coal-handling machinery and boilers to the switch board. It has been repeatedly checked and is confirmed in the paper by Mr. Varney and by many other engineers who have built turbo-electric plants. The gas-engine plant is based upon the actual costs of gas engines and other details and is complete from the gas-cleaning plant at the blast furnace to the switch board inclusive. The great difference of cost comes from the fact that one plant has high-speed rotative machinery and the other has slow-speed and necessarily massive reciprocating engines.

It is possible some great advance in the art may change this present condition of relative cost, but considering the present, we have constructed a diagram, Fig. 68, representing the approximate and relative costs per kw. hour as affected by fixed charges, fuel charges and by operating costs for labor material and repairs. Mr. Stott, in his Toronto paper* divided these more minutely, but this is unnecessary for this disucssion.

W. A. Bole: It might be inferred by a person reading this paper that the gas engine was of necessity a short-lived apparatus without sufficient powers of endurance, and it is timely, I think, that some evidence to contradict this impression should be presented.

The Lackawanna installation is the first of the large installations in this country. I think the next in point of age is the installation by the Westinghouse Machine Company at the Edgar Thomson Steel Works, and the first engine was put in operation there in 1906. I received this morning from the officials of the latter company data which I have not had time to reduce to definite shape, but which I hope may be of some interest. The length of service of four years is sufficiently long, I believe, to point out what may be expected.

The motor cylinders of the Koerting engine are shown to be of cast iron in one piece with water jackets and are provided with an expansion joint. Fig. 17 shows a 38½-in. motor cylinder in detail.

It is my personal belief that the cylinder itself is in need of an expansion joint quite as much as the cylinder head. I doubt the wisdom of an attempt to cast a large gas-engine cylinder integral with its jackets. It presents a problem of considerable difficulty, and I think it is safe to say that the possibilities and limitations of the foundry should be carefully studied at the outset. It is sometimes easy for a designer to put things on paper that the foundryman finds hard to realize in active service.

George A. Orrok*: The Lackawanna plant has a line of blast furnaces, shown in Fig. 1 of the paper. The same drawing shows the engine room, but it does not show what is on the other side of the engine room. On the north side are the Bessemer works. The blast furnaces are about 40 ft. or 50 ft. to the south of the windows on the south side and the Bessemer steel plant is about 60 ft. or 70 ft. from the windows on the north side of the engine room.

On the afternoon on which I visited the plant, four explosions or slips took place, scattering red ore and coke dust. It was in the summer and the windows on the south side were all open and this red ore and coke dust came in and settled over the engines. On the north side there were three 20-ton Bessemer converters working, and the steel dust from those converters was dropping on the engines through the north windows. The pumps were ½ in. deep in steel and ore dust and the edges of the cylinders and the valve parts which moved slowly were covered with ¼ in. of dust. Under these conditions I think the engines have done remarkably well, or that any engine did well that ran at all. I believe nine-tenths of the trouble can be laid to the place where the engines are located.

Now campare the Lackawanna works with certain of the plants in Europe. I had the opportunity last summer of visiting four which are perhaps representative plants. In these works the gas-engine plant is located far enough away from the furnaces to escape dust, and also far enough away from the Bessemer converters. All the windows in the line of flow of the dust are closed and in consequence the engine rooms are clean. The floor is of tile and it is kept clean and the few oilers are simply engaged in the usual work on the machinery. Dust is absent.

(Concluded on page 524)

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*Trans. Am. Soc. M. E., p. 462.

*Trans. A. I. E. E., Vol. 28, p. 1479.

Italy's Position and Views on the Ruhr

The Influence of the Great War Still Strongly Felt. Readjustments in Progress.

By F. A. SHEPLEY*

MILAN, Italy, July 23, 1923—The information in this article is the substance of an interview with the man most interested in the iron and steel trade in all Italy. In addition to having direct interests, he is chairman of all the biggest foundries and machine works.

A clear and concise exposition of the state of this trade in this country—the new and grand "Italia" of today and tomorrow—should eliminate much miscomprehension of this aspect of Italy's activities. We have become so accustomed to hearing such statements as: "The mention of the name of Italy calls up a long pageant of visions of art of every age, of marvelous architecture, of fair scenes flooded by sunshine or bathed in the splendor of the moonlight * * * the spell of its memories and history, etc.," ad nauseum, that we are sidetracked from the facts and realities of the modern life of a nation that is struggling for a place in the sun. But she knows what she wants, and what is still better, she knows how to want—and keep on wanting till she gets it. And in the forefront of those who have great aims and aspirations for Italy are the Italian steel men.

"All countries where the iron and steel trade has reached a certain degree of importance," said the Italian steel magnate interviewed for this article, "have need of iron ore or coal or both these minerals, being, as they are, the very foundation of modern industrial life. Italy, almost wholly deprived of combustibles and endowed, according to most recent statistics, with little more than 40,000,000 tons of excellent ore, has nevertheless known how to give great impulse to this branch of industry. From 1899-1903 to 1909-1913 the average yearly production of iron ore had risen from 205,000 to 535,000 metric tons, cast iron from 15,000 to 334,000 tons, and steel and recast from 249,000 to 1,048,000 tons. While during the last few years of peace the total annual value for the national iron industry has touched a quarter of a billion.

"Her history, then, as will readily be seen, is of the most recent. The pioneers of this industry are to be tracked back to most remote times when, in the heart of the thick forests of Southern and Central Italy, there flourished the old fashioned charcoal blast furnace, and 300 and odd founders among whom were to be counted but few puddling furnaces and many 'low fires' for the founding and smelting of scrap and broken metal. Iron working was nearly all confined to wrought and hammered iron, for there was little or no demand for milled iron from the new mechanical industry.

"Only towards the latter part of the century did the state grant to private undertakings the right to work iron mines in the Isle of Elba. In this brief period of time, these companies, which began so timidly, have become most powerful organizations. This growth was made possible by the ready facilities afforded them by the banks that are likewise of recent formation.

"It is necessary to hark back a few years, in fact until 1910, when to the high furnaces of Portoferraio and Piombino were added the potential and most modernly equipped works of 'Ilva' near Pozzuoli, before we see Italy's iron ore export cease almost entirely; from 170,000 tons in the year 1910 to practically nil for the last 10 years. During the same decade, the consumption of cast iron sprang from 180,000 to 550,000 metric tons, while the production for the same period o ftime assed from 129,000 tons to 732,000 tons of steel. Kept going by the ever growing domestic demand, favored by judicious tariffs and provided with skillful labor and a good market, the industry by 1913 had already paved the way for its own transformation. During the next seven years, the wealth and value of its plants had increased twofold."

A glance at the following table will be instructive and convincing:

THE SIDERURGICAL INDUSTRY IN ITALY, 1920-1923

Year	Number of Works Active	Number of Workmen	Motive Horsepower	Number of Active Furnaces				
					Steel Furnaces			
				High Furnaces for Cast Iron	Martin	Bessemer Converters	Robert Converters	Electric
1923	86	34,592	172,759	12*	67	2	2	7
1920	100	50,000	......	34*	107	1	3	96

*1923: 9 electric. 1920: 11 electric.

"The unexpected accentuation of the demand for siderurgic products did not find the domestic industry unprepared, the only industry upon which the nation count count in war. By the end of the first year of war, 1915-1916, there was a decrease instead of an increase, viz., 220,000 tons of imported steel, that in successive years has slightly exceeded the pre-war figures. The home production of cast iron progressed from an annual average of 334,000 tons for 1909-1913 to 403,000 tons in the five years ending with 1917. Steel rose from 804,000 to 1,102,000 tons for the same period, reaching its maximum production in 1917 with the splendid figures of 1,332,000 metric tons.

"Then the war ceased while the trade was at the full height of its development. The demand for iron and steel products fell off everywhere. In order to avoid what threatened to be a national disaster, all the states took steps to protect their home trade. The question was a grave one for Italy. How could she hope to fight against the British competition that was able, prior to the war, to sell cast iron at Genoa for 10 lire below the cost price of the domestic production, when coal cost twice as much to the Italian as to her more favored rival? Protection was tried in July, 1921, but proved vain and even harmful. It was inevitable that some of the largest companies, owing to their unwieldiness and inelasticity, should come to grief.

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*Staff Correspondent, American Trade Press.

"But for a year our captains of industry have demonstrated their capacity, and have shown that they have rightly comprehended the new situation that, little by little, has been forming. Draconian reductions of capital, the splitting up of some of the huge establishments as being too cumbersome and ill-adapted to the needs of the country, the creating of new and more suitable organs as that of Terni, which has ample supplies of cheap electric power for siderurgic and chemical puroses, were the early manifestations of this new wisdom.

"Greater development of steel production and working is the task that the renewed siderurgic industry has set out to perform. By the introduction of more progressive equipment, by devoting every attention to the economic side of the trade, all wasteful expenditure is being eliminated, which cuts down production cost to a bare minimum. At the same time that this is attained, the country's steel requirements will be satisfied to the great advantage of the general national economy.

"With the proposed reduction of import tariffs on pig and cast iron, and with the intervention of the state in the working of the mines, as that at Cogne, the new government has shown that it is fully alive to the necessities of the nation, and knows how to adapt its commercial policy to the new exigencies.

"Unfortunately, while this transformation was being effected, the German steel and iron trade has been brought to a sudden and disastrous standstill by the French occupation of the Ruhr.

"Although unemployment has been reduced almost 100 per cent, and though our financiers have the utmost confidence in the future of this wonderful industry, a confidence that is clearly demonstrated by the ready manner new shares are taken up, nevertheless there is a certain degree of uncertainty with regard to the effects of the proposed tariffs reform, and also with regard to the lack of a monetary policy that is depressing and disorganizing the money market.

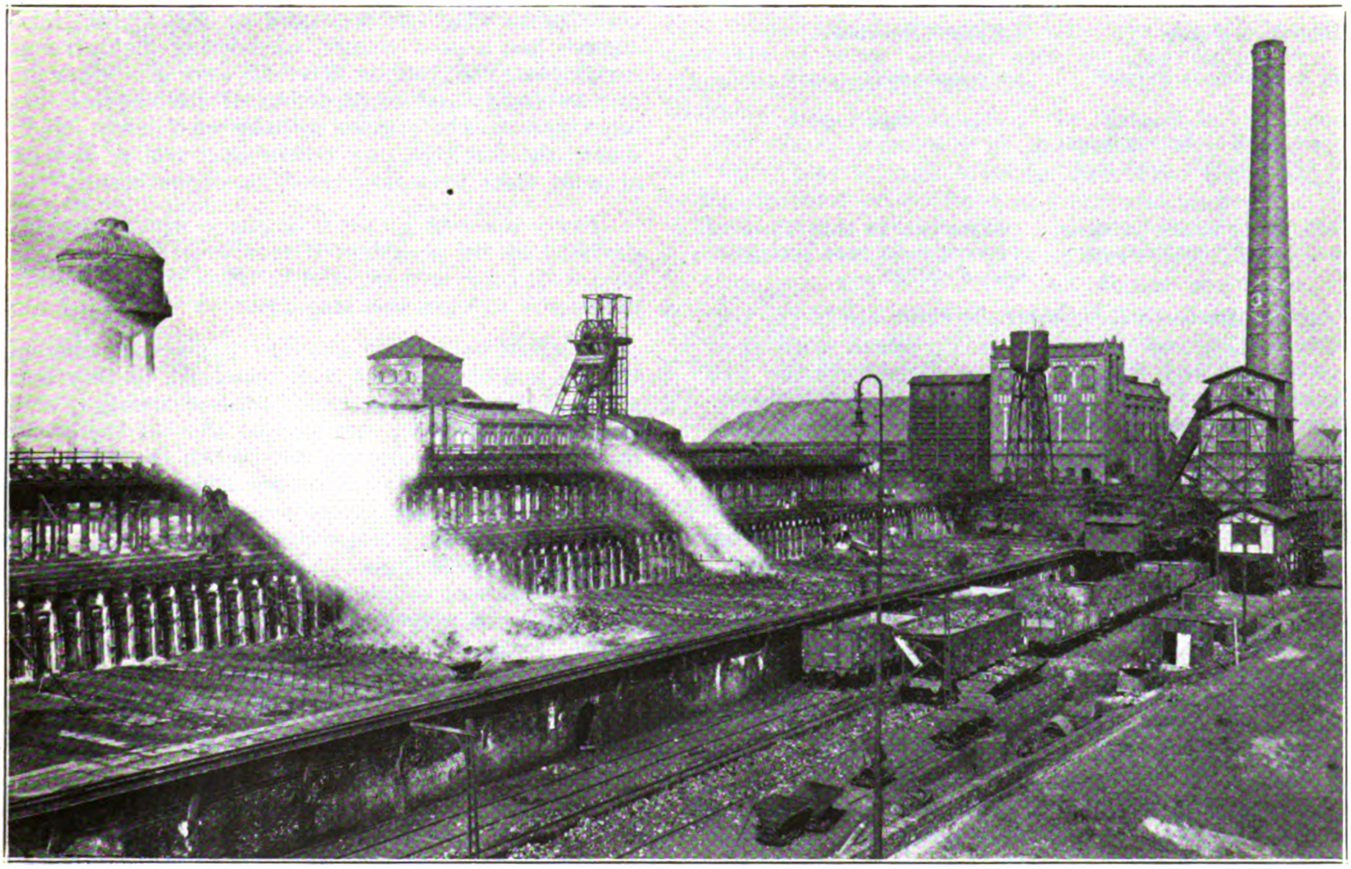
"All these considerations are having a delaying influence and, till the Ruhr question has been settled, it is hardly possible for the siderurgic trade to make headway. Big constructional work, too, is being held up considerably, work which would consume a large part of the metal production."

At this point it will not be out of place to stop and examine some of the figures given, and see where they lead to.

The average production for the quinquennial 1899-1903 compared with the quinquennial 1909-1913 gives the following figures and percentages (metric tons):

Material	1899-03	1909-13	Difference	Pctage. Increase
Iron ore	205,000	535,000	330,000	161
Cast iron	15,000	334,000	319,000	2126.6
Steel and recast	249,000	1,048,000	799,000	320.8
Totals	469,000	1,917,000	1,448,000	308

Thus we see that the average production in all branches in five years had quadruped itself. (This success was due to tariff walls raised against her.) The year 1917 was the one of the greatest production and of importation, since when the generation crisis has caused a falling off.



One of the great by-product coke plants in the Ruhr.

	Production of crude steel tons	Importation crude steel and laminate tons
1917	1,332,000	746,000
1918	979,000	557,500
1919	760,000	384,000
1920	773,000	303,000
1921	683,000	173,000
1922	950,000	113,000

Note: For production, Italy passed from the eighth place to the seventh in 1922.

The Crisis.

This depends upon two things, German unwillingness and French fear, which is here illustrated by comparative columns:

German Unwillingness	French Fear
Payments in kind ridiculously under what her own experts declared she was capable of paying.	America and Britain, by Treaty of Versailles, agreed to aid France in case of attack; this has never been ratified.
The fall of the mark has automatically extinguished internal debt.	France's debt considerably increased. $66,600,000,000.
No foreign debt. (Theoretically 132 billion marks.)	Foreign debt: $16,800,000,000.
German mine owners, industrials and agriculturalists free from improvement tax.	Taxes enormously increased.
Real values of chief resources much increased.	Real values decreased.
Increased birth rate. 1919 births, 212,120; 1921 births, 666,655.	Birth rate decreased or stationary.
Population 65,000,000.	Population 39,000,000.
Emigration rising.	Emigration down.
Big investments abroad.	Comparatively small.
Complains of having to consign cattle, but internal meat consumption greatly increased.	Has to import cattle.
Coal consumption greater than pre-war consumption.	Many works shut down or working short time because of coal shortage.

Again, the German industrials came out of the war almost intact, and were able to go ahead with their work. Italy and France both suffered invasion and had whole towns destroyed which have had to be rebuilt. Few know of the great force exerted by Italy since the armistice to reconstruct the devastated areas. This expense has had to be borne by an impoverished exchequer and by weighting industry with enormous taxes. France is almost in the same plight. What then is the remedy? "Caro Signore, the cure for all our evils—America's no less than Italy's—is in your hands. A merchant swallowed a dollar. So he was a dollar in and a dollar out. Before he could balance his books, an operation was necessary. There is the remedy—an operation. America must return to Europe the position of the man who swallowed the dollar; and take an interest in her. The Unied States are in the position of the man who swallowed the dollar; they have all or most of the world's gold and, as a consequence, cannot export the goods that we need, for money we have none. What America and Britain must do—and will be compelled to do by the ordinary course of events—is to invest in the countries most impoverished, or even to cancel the allied debts completely. Believe me, for the moral effect alone, it will be worth the sacrifice, while from a purely commercial standpoint, the beneficial effects will be incalculable. Confidence will be restored and trade will once more resume its normal course. America will be able to export and so go a long way to settling her labor question. Production—especially in iron and steel—will go up in leaps and bounds, not only for her, but also for the rest of the world, and then, with the different peoples in a healthier frame of mind, disarmament questions and the like can be discussed calmly and dispassionately, and another step in the world's progress will have been made.

"If, however, America remains aloof from a state of things which ex-President Wilson helped to create, the old world will probably muddle through in some way, but in the meantime she will have learned to do without many of your products and make them herself, and you will be the poorer—morally and economically.

"As iron and steel are the rock bed upon which the fabric of modern society is built, so, too, must the iron and steel men lead the way to enlightenment, and by them must be assumed the responsibility for the reconstruction of the world renewed."

First Large Gas Engines

(Continued from page 521)

E. A. Uehling: I visited the gas engine plant of the Lackawanna Steel Company on several occasions and can corroborate what has been said by Mr. Orrok, that the engines had a poor chance, considering the surrounding conditions. The troubles they had were in a lesser degree due to design and construction of the engines than to other causes. The greatest mistake was, in my judgment, due to the fact that they put in such a large installation at once; there were no trained gas-engine men.

Every machine speaks a language which must be understood by the attendant if trouble is to be anticipated before damage is done, and it takes time and intimate experience to learn this language.

Much of the trouble was due to imperfect cleaning of the gas and also, as has been remarked, to very unclean air, but probably the most serious damage, that is knocked-out cylinder heads, was due to the variation in the composition of the gas. When they first started they had only two blast furnaces, and when one of these furnaces had a leaky tuyere the percentage of hydrogen became excessive, pre-ignition took place and cylinder heads were knocked out. While every blast-furnace man understands that water getting into a furnace through a leaky tuyere is a very bad thing he appreciates even to a greater extent the fact that the furnace must be kept in operation. Consequently a leaky tuyere was left until flushing or casting time, meanwhile making high hydrogen gas, to the detriment of the gas-engine plant. When the furnaceman became aware of the consequences, the leaky tuyeres were at once removed and his trouble very largely avoided. It was entirely overcome when more blast furnaces went into operation. At later visits I was informed that the gas-blowing engines gave no more trouble than steam-blowing engines doing the same work.

Refractories in the Steel Industry

No Single Element Is More Important Than Refractories. A Summation of Important Data.

By J. SPOTTS McDOWELL*

PART I

REFRACTORIES are of vital importance to the iron and steel industry. Without firebrick, various industrial processes requiring high temperatures could not be performed. "The blast furnace and blast furnace stove are merely huge stacks of firebrick enclosed in steel shells."* The open hearth furnace is composed of various refractory materials, properly stayed. The boiler furnace, the soaking pit, the heating furnace, the by-product coke oven —all these are merely structures built of refractories, and so designed that processes involving more or less intense heat may be accomplished in them.

The kind and quality of refractory material most suitable in any particular case, will be determined by these factors:

A. Is the temperature high (above 2600 deg. F.). moderate (2300 deg.-2600 deg. F.), or low (below 2300 deg. F.)? Are the refractories heated from only one side, as in a wall, or from all sides, as in checker-work?

B. Is the process continuous or intermittent? Are the temperature fluctuations rapid or slow?

C. Does flame come into contact with the refractories? Is there a sharply impinging or cutting flame, with localized areas of intense heat?

D. What gases, if any, come into contact with the refractories? Are they clean, or laden with dust, and what is their velocity?

E. Are the refractories acted upon chemically by molten metals, or by fluxes such as slags, clinker from coal ash, or dust or fumes carried by furnace gases? What is the chemical character of the fluxes? Are they strongly corrosive or only mildly so? Are they solid, viscous or liquid at furnace temperatures?

F. Are the refractories subjected to heavy load or to abrasion at high temperatures?

G. Is heat to be conducted or retained?

H. Need electrical conductivity or dielectric strength be considered?

The best material for any particular purpose is generally determined by one or two essential requirements, while the others are usually of minor importance. For certain uses, the brick must nave a high melting point and resistance to rapid temperature changes; for others, these properties may be unimportant, and a brick of exceptional rigidity at uniform, but only moderate temperatures may be required. In some cases, high thermal conductivity is necessary; in others, high insulating value.

In the selection of refractories, less important properties must often be sacrificed in order to secure the properties required, as no one refractory can meet all of the possible furnace conditions. Moreover, in the manufacture of brick, certain properties may be secured at the expense of others; for example, increasing the density of fireclay brick will usually result in lowering the resistance to rapid temperature changes.

The materials available to meet the various industrial requirements are silica-alumina, silica, magnetite and chorme refractories, and various special refractories of limited application.* The silica-alumina refractories include: (1), flint and plastic clay brick, containing from about 50 to 70 per cent silica and up to 45 per cent alumina; (2), silicious clay brick, containing approximately 70 per cent or more of silica; and (3), high-alumina brick, containing more than 45 per cent alumina.

When the term "firebrick" is used alone, it is generally understood to mean fireclay brick. Of these, the flint and plastic clay brick are by far the most widely used.

Clay Refractories.

Pure clay theoretically has the composition Al_2O_3 . 2 SiO_2 . 2 H_2O, corresponding to 39.8 per cent Al_2O_3, 46.3 per cent SiO_2 and 13.9 per cent H_2O. At high temperatures the water is driven off, and the corresponding analysis is 46.2 per cent Al_2O_3, 53.8 per cent SiO_2. Even the purest of clays contain small amounts of other oxides, such as iron oxide, lime, magnesia, titania and alkalies.

Clays.

The clays important in the refractories industry are flint, plastic, and silicious fireclays; these vary widely in their proportions of silica and alumnia, and in their content of impurities. Most of the high-grade firebrick are composed largely of flint clay. The clays of this type are very hard and dense, and usually break with fairly smooth surfaces and sharp edges. Their plasticity and drying shrinkage after being ground and mixed with water are very low; the burning shrinkage is fairly high and somewhat variable. The cone-melting point of the best flint clays is cone 33 to 35.† The most important deposits are found in rather limited areas in Central Pennsylvania, Maryland, Southern Ohio, Eastern Kentucky and Eastern Missouri.

The semi-plastic and plastic refractory clays vary considerably in plasticity, bonding power, and refractoriness. The drying and burning shrinkages are as a rule fairly high. The cone-melting point of the best clays ranges from cone 30 to cone 33; of some very good plastic clays, cone 26 to cone 30; and of the least refractory varieties, cone 15 to cone 26. Most of the deposits occur in the carboniferous series of rocks, either associated with the flint clay or somewhat higher in the geologic series.

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*Research Engineer, Harbison-Walker Company, Pittsburgh, Pa.

*H. W. Croft, Use and Development of Refractories in the Iron and Steel Industry, Year Book of the American Iron and Steel Institute, 349 (1913); Iron Trade Review 53, 1138 (1913).

*Liddell's Handbook of Chemical Engineering, Chapter on Refractories by A. V. Bleininger, Vol. 1, p. 473 (1922).

†The cone method of measuring temperatures and a table of cone melting points are given later in this paper.

The high silica content of the silicious fire clays is due to the admixture with the clay of fine quartz sand. The free silica is readily acted upon by basic flues, and the clays must therefore be low in impurities to have refractory value. Silicious clays are best represented by the clays of New Jersey, which are of a later geologic age than the flint and plastic clays of Pennsylvania.

Firebrick.

The ingredients used in making flint clay brick are hard or flint, bond or plastic, and calcined clays. In a general way it may be said that the function of the flint clay is to impart refractoriness and low drying shrinkage; that of the bond clay is to give strength and toughness and that of the calcined clay is to diminish both drying and burning shrinkage and thus decrease the tendency of the brick to crack or warp during drying and burning.

The relative proportions of the three ingredients in the mix depend upon the character and quality of the brick to be made. In many mixes no calcined clay is used; in others there may be as much as 50 per cent. In the best grades of brick only a small amount of bond or plastic clay is used unless this is extremely pure.

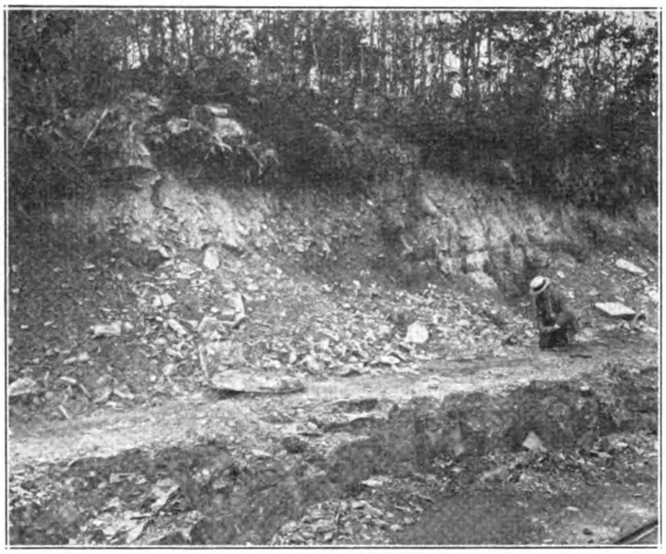

FIG. 1—*Bed of flint clay near outcrop with overburden light enough to permit stripping. The clay is about three feet thick. (Cambria County, Pa.)*

Flint clay brick may be made either by hand or by machine. Typically, hand-made brick are made by grinding the clay batch in a wet pan, followed by hand-molding, partial drying upon the hot-floor, and repressing by hand. For "Steam-Pressed" brick the clays are ground in a dry pan, mixed and tempered in a mixer, extruded through the die of a plunger or auger machine, wire-cut and pressed in a power-press. In making dry-press brick the clays are ground in a dry pan with a small amount of water, and fed to a dry-press in which five or six brick are molded at a time. The brick made by any of these processes are dried either on a hot floor or in tunnel driers, and burned in rectangular or circular down draft kilns to cone 8 to 15, depending upon the kind of brick and the burn desired. Hand-made and machine-made brick differ in texture, density and other properties.

The degree of burning is indicated by the terms "hard burn", "medium to hard", "medium" and "light to medium". For general mill work brick are either "medium to hard" or "hard burn"; roof brick are usually given a "medium" or "light to medium" burn. Second and third quality brick are nearly always hard-burned.

Plastic clay refractories are made of plastic clay with the addition of little or no flint clay. They are generally formed by machinery and burned at cone 4 to 8. Silicious clay brick are usually made by the auger machine process and burned to about cone 8.

Silica Refractories.

In making silica brick, hard and dense quartzite low in impurities is used. The most important deposits are those of the Medina formation in Pennsylvania, the Baraboo of Wisconsin, and the Weisner of Alabama. There is little difference in their composition. A typical analysis follows:

SiO_2	97.50
Al_2O_3	0.95
Fe_2O_3	0.90
CaO	0.09
MgO	0.25
Alkalies	0.28

The rock is crushed, ground in a wet pan with the addition of 2 per cent lime as milk of lime, molded by hand, dried in tunnel driers, and burned in coal-fired circular down draft kilns to cone 17 to 18. The time required for burning and cooling is 18 to 20 days. The kilns are 30 to 40 feet in diameter, and hold 70,000 to 165,000 brick, expressed in standard 9-inch equivalent.

In the burning of silica brick two important changes occur: The brick become strongly bonded and acquire a permanent expansion of ⅜-in. to 7/16-in. per foot. This expansion is caused by the fact that quartz, with a specific gravity of 2.65, goes over at high temperatures to other forms of silica, known as cristobalite and tridymite, with specific gravities of 2.33 and 2.28. The linear expansion corresponding to the change from quartz to cristobalite is 4.35 per cent; quartz to tridymite 5.3 per cent. It would be desirable to change the quartz in burning entirely to tridymite, but this cannot be done commercially, as the change goes to completion with extreme slowness. Commercial silica brick made from the Medina rock, consist approximately of 70 per cent cristobalite, 10 per cent tridymite, about 8 per cent of silicates and 12 per cent residual quartz.

In service, the cristobalite and residual quartz may gradually change to tridymite, and cause a slight additional permanent expansion of the brick. The thermal expansion curve of cristobalite shows an abrupt and considerable volume change at 230-270 deg. C.; rapid changes of temperature within this interval, are therefore likely to cause cracking or spalling of silica brick.

High-Alumina Refractories.

High alumina refractories are made from bauxite or diaspore, either alone or bonded with clay. The process of manufacture is similar to that of clay brick. Burning is a greater problem, however, on account of

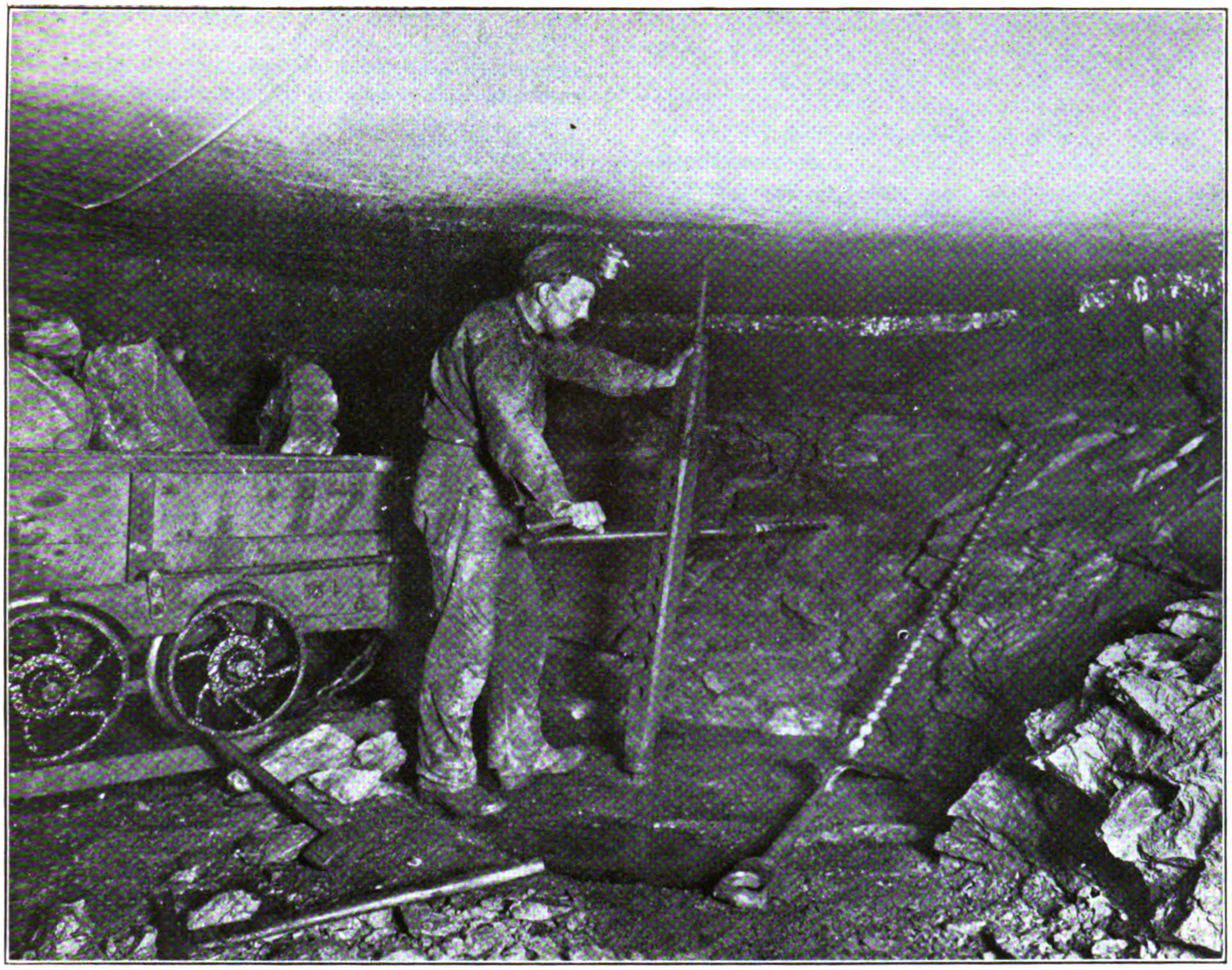

FIG. 2—*Interior of flint clay mine at Woodland, Pa.*

the difficulty of completely shrinking the material in the kiln, so that no injurious additional shrinkage will occur later in service. The different grades of high-alumina brick on the market contain approximately 56 per cent, 65 per cent and 75 per cent Al_2O_3.

Magnesite Refractories.*

The raw material of the magnesite refractories industry is the mineral magnesite, which theoretically contains 47.6 per cent MgO and 52.4 per cent CO_2. Two types occur, the dense and the crystalline. Except for a brief period during the war, the crystalline magnesite almost exclusively has been used in the manufacture of refractories. It occurs in large deposits in Austria and Czecho-Slovakia and in Washington state. The waste in quarrying usually amounts to about 50 to 60 per cent of the material mined.

The first step in making magnesite refractories is "dead burning" the crude material. This consists in heating or calcining it to a temperature high enough to drive off the CO_2 and to form a dense sintered product inert to atmospheric moisture and CO_2. Dead-burning is aided by the presence in the magnesite of a small percentage of iron oxide; this occurs naturally in the Austrian and Czecho-Slovakian magnesite and is added to the Washington magnesite in the form of iron ore before calcining.

Dead-burned magnesite is marketed in the form of a mixture of nodules or grains varying in size from pieces about ⅝-in. in diameter to very fine particles. It is used for the construction of monolithic hearths in furnaces, and for the manufacture of brick.

Typical Analyses of Dead-Burned Magnesite

	Austrian	Washington
MgO	85.6	83.1
Fe_2O_3	7.1	5.0
CaO	2.9	3.1
SiO_2	2.8	6.3
Al_2O_3	0.6	2.0

In the manufacture of magnesia brick the dead-burned magnesite is ground fine, mixed in a wet-pan with a small amount of water, molded in a power press, dried in a tunnel drier and burned in rectagular down-draft kilns to about cone 20. To prevent distortion in burning they are boxed in with silica brick in such a way that there is practically no load upon them. On account of the way in which they must be set, only about 12,000 magnesia brick can be placed in a kiln large enough to hold 30,000 clay brick. This adds materially to the expense of setting and burning.

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*McDowell and Howe, Magnesite Refractories, Jour. Am. Cer. Soc. 3, 185 (1920).

Metalkase magnesite brick consist of steel cases open at the ends and packed with dead-burned magnesite.

Chrome*.

Chrome refractories are manufactured from the mineral chromite, FeO, Cr_2O_3, which theoretically contains 67.9 per cent Cr_2O_3 and 32.1 per cent FeO. However, even the purest ore rarely contains over 60 per cent Cr_2O_3 and ores containing 35 per cent or less are common. The diversity of composition is explained by the fact that chrome ore is an isomorphous mixture of various minerals of the spinel group in varying proportions, in which Cr_2O_3 may be replaced in part by Al_2O_3 and Fe_2O_3, and FeO by MgO.

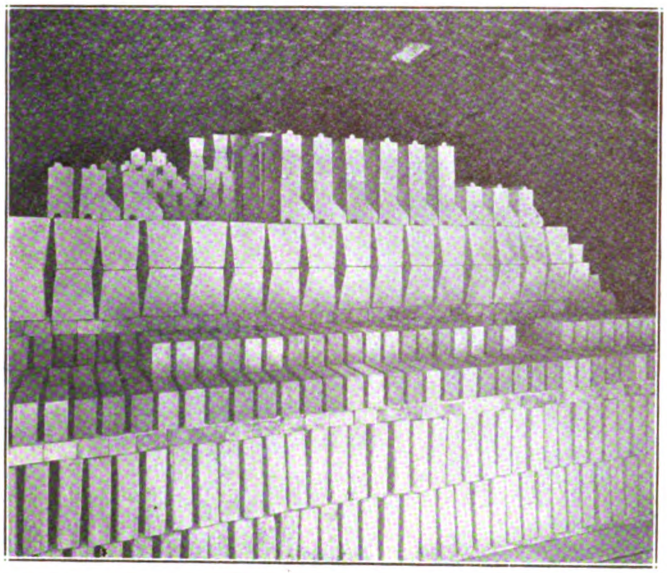

Fig. 3—*Interior of rectangular firebrick kiln showing method of setting brick for burning.*

Chromite is very hard and heavy, with a specific gravity of about 5:17. The process of manufacture of chrome brick is similar to that of magnesia brick. Ores of the following approximate analyses are used in the United States as refractory materials.

	A.	B.
Cr_2O_3	40.8%	44–48%
FeO	17.8	14
MgO	14.9	15
Al_2O_3	22.4	12
SiO_2	3.7	5–8

Properties of Refractories—Chemical Properties.

Refractories are commonly classified as basic, neutral and acid. Magnesite is basic; chrome and the high-alumina refractories are classed as neutral although acted upon by either strong acids or strong bases; fireclay brick is mildly acidic and silica brick strongly acid. Generally speaking, basic refractories are most resistant to basic fluxes; and acid refractories to acid fluxes. However, other factors which have a decidedly important influence upon the resistance of refractories to fluxing action are the refractoriness, porosity, texture and hardness of the brick; the furnace temperature; and the condition of the flux (whether solid, viscous, or liquid). Lime kilns furnish an illustration of a practice in which a highly basic charge is successfully treated in a furnace with an acid (silica) lining. Silica brick are used in the crowns of practically all glass tank and open pot furnaces, although subjected to the alkaline vapors from the glass batch.

For greatest resistance to fluxes, the refractories should be hard and dense. On account of their high density and low porosity, brick made of plastic clay resist slag action well where the temperatures are not too high.

The tentative slag test of the American Society for Testing Materials (Serial Designation C 17-19 T) consists in placing 35 grams of pulverized slag within a clay ring upon the brick to be tested, after the brick has been heated to 1350 deg. C. (2462 deg. F.). This temperature is maintained another two hours. When cold the brick is sawed through the center of the ring and the area of slag penetration determined.

According to recent work of Howe and collaborators* the A. S. T. M. method is likely to give misleading results. These investigators have made a series of tests in which the fusion points were determined of definite mixtures of brick and slag. In these tests the most corrosive slags had the greatest effect in lowering the melting points of the brick. Silicious fire clay brick appeared to have a lower resistance to several slags than did silica or flint clay brick.

Magnesia brick and fireclay brick react chemically with each other at approximately 2775 deg. F. (1525 deg. C.), with the formation of a thin liquid slag. Between magnesia and silica brick the reaction is less severe, and appears to begin at about 2900 deg. F. (1595 deg. C.). Dead-burned magnesite is not injured by exposure to the air, but rapidly slakes to powder when acted upon by steam. Calcined and sintered dolomites tend to slake upon exposure to the air.†

Fusion Point.

Silicates such as clay have no definite melting points, as metals have, but soften gradually under the influence of heat. For that reason, the so-called melting point of certain refractories is merely the temperature at which a definite degree of softening has occurred.

The method of determining this softening temperature, as prescribed by the American Society for Testing Materials, consists in using cone-shaped test pieces of known composition and melting point, known as standard pyrometric cones. In determining the fusion point of any given material, it is made up into a cone similar in size and shape to the standard cones, and is heated with several of these at a definite rate. At the time the cone made of the material to be examined softens and bends, a record is made of the standard cone which shows the same degree of softening. The approximate temperature corresponding to this standard cone is found in the tables.

The original scale of cone-melting points was in error above cone 20 and the indicated temperatures were too high. For cone 35 the difference is 75 deg. C., or 135 deg. F. Users of the cones had by long use become accustomed to thinking of the melting points in terms of the original figures and these are still widely used, although the revised figures are known to be more accurate.

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*McDowell and Robertson, Chrome Refractories, Jour. Am. Cer. Soc. 5, 865 (1922).

*Howe, Phelps and Ferguson, the Action of Slag upon Silica, Magnesite, Chrome, Diaspore and Fireclay Refractories, Jour. Am. Cer. Soc. 6, 589 (1923).

†McDowell and Howe, Magnesite Refractories, Jour. Am. Cer. Soc. 3, 185 (1920).

When the standard or test cones are heated rapidly, they soften at a higher temperature than when heated slowly. For that reason, the rate of heating prescribed by the A. S. T. M. should be followed. Cone 20, which normally softens at 1530 deg. C. (2786 deg. F.), has been observed to soften at 1450 deg. C. (2642 deg. F.), after long continued heating. The same effect may be observed in the heating of certain brick, which in time will deform under their own weight at temperatures which cause no immediate effect.

FUSION POINTS OF REFRACTORY BRICK*

Material	Cone	Revised Deg. C.	Scale Deg. F.
Firebrick: Flint and plastic clay			
High refractoriness	31-34	1685-1740	3065-3164
Intermediate "	28-31	1635-1685	2975-3069
Moderate "	26-28	1600-1635	2912-2975
Low "	19-26	1510-1605	2750-2921
Firebrick, silicious, best grades	28-31	1635-1685	2975-3069
High Alumina brick	34-40	§1740-1845	§3164-3353
Silica brick	32-33	1705-1720	3101-3128
Magnesia†	....	2165	3929
Chrome†	....	2050	3722

Permanent Expansion or Contraction‡.

The problem of the volume change of refractories can be stated thus: In the burning of the brick, a volume change occurs, altering them from the mold or "green" size to the required or "burned" size. It is desirable that the permanent change in volume be completed in the burning, so far as industrially possible, so as to prevent excessive further change later in service. In every burned brick a true thermal expansion occurs upon heating, identical with the expansion accompanying the heating of practically all bodies. Such thermal or temporary expansion disappears upon cooling and is unavoidable; it is not to be confused with the change in volume of the brick during its manufacture. When the burned brick are later heated in service, there will be not only a thermal expansion, but also, if the furnace temperature be high enough, a slight additional volume change of a permanent character. It is not usually practicable to carry this volume change to completion in the initial burning. However, excessive changes in volume in service may be harmful, on account of the effect upon the refractory structure. The general tendency of high alumina refractories is to shrink somewhat in time at high temperatures; that of silica is to expand.

According to the A. S. T. M. standard definitions for clay refractories, clay firebrick should not expand more than 1 per cent nor contract more than 1.5 per cent in length after being heated for 5 hours at the following temperatures:

	Deg. C.	Deg. F.
Intermediate heat duty brick	1350	2462
High heat duty brick	1400	2552
Moderate heat duty brick	1290	2354

Thermal Expansion.

The thermal expansion of clay, magnesia and silica brick are shown in the curves of Fig. 9. The expansion of chrome brick is high, amounting to about 3/16-in. to 7/32-in. per foot at furnace temperatures.

Porosity.

The porosity of refractories is influenced by various factors, among which are the character and quality of the material, the fineness of grinding, the water content at time of molding, the pressure of molding, and the time and temperature of burning. The porosity in turn has an effect upon the resistance of the brick to temperature change, the rigidity under load at high temperatures, the thermal conductivity and resistance of the brick to slag action.

FIG. 4.—*Floe of medina quartzite (ganister), in Jack's Narrows, Huntingdon County, Pa., near Mt. Union.*

Porosities by Volume, Average Values.

Flint-bond clay brick, hand made	20-30%
Flint-bond clay brick, machine made	15-24
Silicious clay brick	20-30
Plastic clay brick—often as low as	33
High-alumina brick	29-33
Silica brick	22-32
Magnesia brick	24-30

Specific Gravity.

The specific gravity of refractories is dependent upon the character of the material, and the time and temperature of burning. With some materials, such as magnesia and silica, it is a measure of the completeness with which the molecular changes brought about by heat have taken place.

The specific gravity of magnesia brick is 3.44 to 3.60, averaging about 3.52. The specific gravity of amorphous magnesia is about 3.2, that of crystalline magnesia 3.67 therefore a high specific gravity of magnesia brick indicates that the material is completely shrunk.

(Continued in November.)

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*See A. S. T. M. Standard Definition for Clay Refractories (Serial Designation C 27-20).

†C. W. Kanolt, Melting Points of Firebrick, U. S. Bureau of Standards Technologic Paper 10, (1912).

‡Kenneth Saver, Manufacture and Tests of Silica Brick for the By-Product Coke Oven, Trans. Am. Inst. Mining Eng., 53 125 (1916).

§Approximate.

Electric Drive for Centrifugal Fans, Blowers and Propellor Fans

Characteristics of Fans Operated at Various Percentages of Rating with Curves Showing Pressures, Velocity Heads, Horsepower Required, Efficiencies

By **GORDON FOX***

PART II.

FAN characteristics are besed on constant speed conditions. If the speed of a fan varied with load, due to the speed regulation of the motor, the fan characteristics may be considerably influenced. The effect of drooping speed regulation is to increase the slope of the fan pressure characteristics. The fact has been previously mentioned that, due to decrease of pressure developed at excess volume, the load of some fans will not greatly exceed rated load. This characteristic can be accentuated through use of a motor having drooping speed regulation, such as a compound wound motor or a wound rotor induction motor with a small amount of fixed secondary resistance in circuit.

The use of the compound wound motor is to be advised for fan drives in case the system voltage is subject to considerable fluctuation. Fan drives ordinarily have considerable inertia, leading to high current peaks in a motor subject to fluctuating voltage.

Motors for adjustable speed service are considered in subsequent paragraphs.

Speed Control.

The delivery of a centrifugal fan, blower or compressor may be reduced by throttling the inlet or discharge by a damper. This increases the system pressure and causes the fan to operate at a higher pressure and lower volume point on its characteristic. This condition is indicated in Fig. 1, wherein Curve C is the normal system characteristic with damper open. The fan, operating at the intersection of Curve B, representing static pressure developed, and Curve C, representing static pressure required, delivers 100 per cent capacity at 100 per cent pressure. If the system pressure required is increased to Curve F, by partly closing the damper, the fan will deliver 80 per cent of rated volume and will develop 130 per cent normal pressure. The power required under normal conditions is 100 per cent, and at 80 per cent volume 87 per cent of rated power is required.

Fig. 2 gives the characteristics of the same fan operated at 80 per cent of rated speed to deliver 80 per cent of rated capacity. System Curves C and E are the same as in Fig. 1, and no damper is used. It is to be noted that 80 per cent volume is here obtained with 64 per cent of rated pressure and 51 per cent of rated horsepower. In the first case the fan operates at about 48 per cent static efficiency and in the latter case it operates at 40 per cent static efficiency. The overall efficiency is higher and the power required is lower in the latter case, however, due to the avoidance of excess losses in air friction due to the use of a damper.

In general it may be said that, where volume is reduced by a damper, the mechanical power required is reduced roughly in proportion to the volume. If volume is reduced through decrease in motor speed, the mechanical power required is reduced about as the cube of the volume. Throttling by a damper is not an efficient practice. This method is in quite common use in connection with constant speed drives, but where considerable powers are involved, where continuous volume control is necessary, or control over a rather wide range, the use of speed adjustment offers considerable advantage and saving.

A number of methods are employed to obtain speed adjustment for fan drives. Where d.c. is available, speed adjustment may take one of three forms, namely:

Regulation by armature resistance.
Field control.
Combination control.

Armature control is obtainable at the lowest first cost because the normal speed of the motor then corresponds to maximum speed of the fan and a smaller motor frame may be used to deliver the required horsepower than when the motor is rated at a lower speed. The cost of the control equipment required for this method of regulation is somewhat higher than when field control is used, but this does not offset the difference in motor costs.

Armature control is relatively inefficient in operation The losses in series resistors are not proportional to the speed reduction, but increase more slowly to a maximum of about 15 per cent of motor rating at 60 to 70 per cent speed. As the power required to drive a fan varies as the cube of the speed, halving the speed reduces the power requirements to one-eighth of that corresponding to full speed. Hence the wastage of power at reduced spec[illegible] with series resistance control is less serious, for a fan [illegible]ve, than for a load having a constant torque characte[illegible]tic. The extent of the resistor losses for a fan dri[illegible] is shown in Table I.

TABLE I

Losses in Resistors for a d.c. Motor or Wound Rotor Induction Motor Driving a Centrifugal Fan, Blower or Compressor at Reduced Speeds

Pct. Rated Full Load Speed and Volume	Fan. hp. Pct. of Rated hp. of Motor	Elec. Input Pct of Input at Full Speed	Resistor Losses	
			Per cent of Input	Per cent of Rated hp. of Motor
100	100	100	0	0
90	72.8	81	10	8.2
80	51.2	64	20	12.8
70	34.2	49	30	14.7
60	21.6	36	40	14.4
50	12.5	25	50	12.5

Note:—This table does not take into consideration losses within the motor, which fall off slightly at reduced speeds.

Field control generally involves higher first cost for the reason that an adjustable speed motor is essentially a

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*Electrical Engineer, Freyn, Brassert & Company, Chicago, Ill.

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constant horsepower unit. Therefore the rated horsepower of the motor must be that corresponding to full speed of the fan while the rated speed of the motor corresponds to minimum fan speed. However, since the greatest load does not occur at low speed, and since modern adjustable speed motors will carry slight overloads safely at increased speeds, it is permissible to motor closely or to use a motor having a higher rating at high speed than at low speed. Such ratings are given by some motor manufacturers.

The selection of the proper type of d.c. equipment depends upon the range of speeds desired, the extent of operation, the prevailing operating speeds and the cost of power. For small motors narrow speed ranges and cheap power conditions, the lower first cost of an armature control installation will generally justify its selection. Where the motor operates for long intervals at speeds between 50 per cent and 100 per cent maximum speed, field control will show sufficient economy to justify its greater first cost. If the motor operates long intervals at speeds between 75 and 100 per cent and occasionally at lower speeds, combination control is best suited. Combination control is commonly arranged to afford 10 to 25 per cent speed adjustment by field control and about 50 per cent speed reduction by armature control.

Where speed control is desirable and a.c. only is available, the wound rotor induction motor with secondary resistance control is most commonly used. This method of driving parallels the d.c. motor with armature resistance control. Due to the usual steady load of a fan, this method of control ordinarily supplies a sufficiently constant speed at any setting in spite of the drooping speed-regulation characteristics. As fans ordinarily operate continuously for long periods the inefficiency of this method of driving may be an important consideration. The resistor losses at reduced speeds are shown in Table I. This method of drive is ordinarily considerably more efficient than constant speed drive with damper regulation. A comparison for a given set of conditions may be made, based on the fan characteristic and Table I. Except for some shortcomings in the matter of efficiency this method of drive is ordinarily entirely satisfactory. Due to conversion losses of 20 to 25 per cent, it is ordinarily more efficient to drive with a wound rotor induction motor with secondary resistance control than to convert to d.c. in order to use field control.

In some cases the resistor losses are of sufficient magnitude to warrant the installation of a brush shifting type of polyphase series motor. This motor has a speed characteristic very similar to that of the wound rotor induction motor but, at considerably reduced speeds, the efficiency is higher and the power factor also may be better. This type of motor is relatively expensive. Whether or not its higher first cost is justifiable must be determined for each case through a study of comparative economies under prevailing conditions. The brush shifting type of motor is available in sizes up to 175 hp. at 1,200 rpm. and 350 hp. at 600 rpm.

In the case of very large fans, such as used for mine ventilation, speed adjustment may be desirable primarily due to extension of the mine workings. In many cases the fan speed is occasionally changed by adjustment of pulley sizes. If a motor of adjustable speed type is desired the use of Kramer or Scherbius sets is frequently warranted due to the large powers involved and the continuity of operation, which render the matter of power cost important. The constant torque type of set is applicable, but the actual fan load characteristics should be considered in determining the capacity of the auxiliary equipment.

Starting Considerations.

The starting torque required by a fan or blower is ordinarily low. In the case of large, slow speed fans the static friction may be rather high. In most cases there is considerable inertia load involved in accelerating the fan. Starting resistors for use with controllers for large fans may require extra heat dissipating ability due to slow acceleration necessitated by high inertia load. The air delivery load is practically nil at starting and builds up as the fan and motor attain speed. If the centrifugal fan starts with discharge closed, the maximum air load taken in churning at shut-off pressure is ordinarily about 25 per cent of rated load. It is advantageous to start any large fan under shut-off conditions to minimize the accelerating current demand, but this practice is particularly desirable when synchronous motors are used. Synchronous motors have been employed to start fans under load conditions with damper open, but they are likely to be larger and more expensive than when more favorable starting conditions may be afforded. A self-starting synchronous motor for driving a fan should have a low resistance cage winding capable of dissipating considerable heat. The low cage resistance is allowable because of the low static torque and is desirable to enable the motor to approach closely to synchronous speed by induction motor action and thus minimize the pull in requirement, which is rendered more severe because of the inertia of the drive.

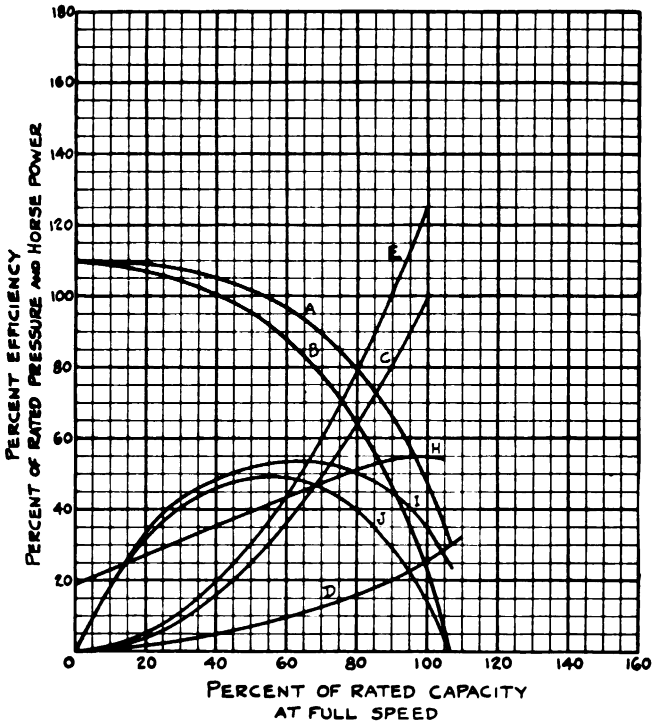

FIG. 2—*Characteristics of fan shown in Fig. 1—driven at 80 per cent rated speed to reduce discharge to 80 per cent normal.*

A—Per cent of rated total pressure developed.
B—Per cent of rated static pressure developed.
C—Static pressure required by system—normal.
D—Velocity head.
E—Total pressure required by system—normal.
H—Per cent of rated horsepower required.
I—Per cent total efficiency.
J—Per cent static efficiency.

Automatic control is frequently supplied for fan drives. This may be arranged to respond to pressure or vacuum gauges for starting and stopping and diaphragm regulators for speed control. Under voltage release may often be desirable as contrasted with under voltage protection to afford automatic starting and insure maximum continuity of service. Line switch control is sometimes used, in which case the motor starts automatically when the feeder switch is closed and runs so long as the power remains on the line.

Mechanical Connection.

Small fans are adaptable to fairly high speeds and are well suited for direct drive. In the case of the smaller fans with one inlet, the fan wheel may be overhung on the motor shaft, which is extended for the purpose. Some larger fans are mounted on an extended shaft carried from a single bearing on the drive side, such construction being necessary where. hot gases, smoke, etc., make it impossible to locate a bearing on the inlet side. It is preferable, whenever possible, to place a bearing on the side of the fan farthest from the motor. A three-bearing arrangement, with one bearing on the fan and a short fan shaft with solid coupling to the motor shaft is commonly used because of low cost and compact arrangement. With this construction accurate and well maintained alignment is important. Two bearing fans with flexible coupling between fans and motor represent the best type of construction for the larger and more important work. Where a high speed fan may be subject to unbalancing, due possibly to corrosion, erosion or clogging, the use of a flexible coupling or a belt drive may be desirable to relieve the motor. In many cases the fan builder provides a structural and sheet metal extension to the bed plate to receive the motor. In some cases this is made too light and permits motor vibration.

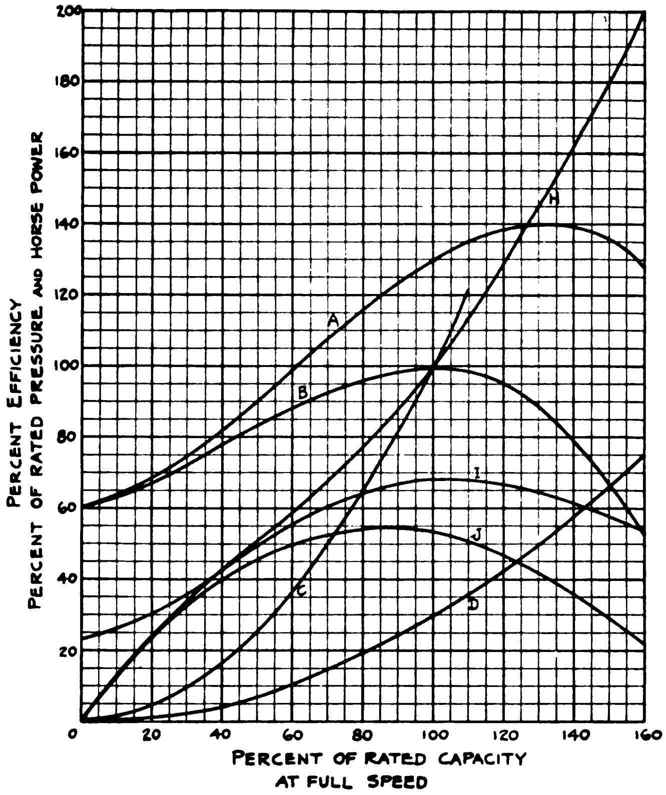

FIG. 3—*Characteristics of a multiblade fan having a rising pressure characteristic.*

A—Per cent of rated total pressure developed.
B—Per cent of rated static pressure developed.
C—Static pressure required by system.
D—Velocity head.
E—Total pressure required.
H—Per cent of rated horsepower required.
I—Per cent total efficiency.
J—Per cent static efficiency.

The larger centrifugal fans run normally to slow speeds. D.c. motors suitable for direct connection are available. They are somewhat special and relatively high in cost. Suitable slow speed induction motors are not available for the slower speeds and they would have rather low efficiency and very poor power factor if constructed. Synchronous motors may be obtained for slow, constant speed drives, having excellent characteristics. Where sufficient space is available, belt drive can be used to advantage, utilizing higher speed motors. Belt drive offers a number of advantages, aside from permitting the use of high speed motors. Where a centrifugal fan is to exhaust into a system of ducts, the delivery of the fan and its consequent load may be difficult to predetermine with sufficient accuracy to permit direct connection with no means of speed adjustment. For such a condition belt drive offers the advantage that an adjustment may be made readily by the simple expedient of a small change in pulley diameters, thus correcting for any error in predetermining conditions. Belt drive has a further advantage in that it prevents noise from the motor being transmitted to the fan and carried into the ducts. In office buildings, etc., such noise is objectionable. The above applies particularly where induction motors are used as they tend to be more noisy than d.c. motors. Belt drive or other remote connection may sometimes be desirable to protect a motor driving a fan handling hot gases.

Propeller Fans.

Propeller type fans commonly operate at constant speed. For small units single phase motors are applicable. Squirrel cage induction motors are commonly employed for a.c. drives. For d.c. drives, shunt-wound motors are commonly used on the larger units. Series motors are frequently applied on the smaller fans, overload by slowing down under load increase. Small series motors driving fans can be started by connecting directly across the line. The series motors develop high starting torque per ampere input and the starting load is small. The power required by a propeller fan may be determined by the same formula as that given for centrifugal fans. A formula based on fan dimensions and speed is given below:

$$HP = C \times \frac{D^5 N^3}{10^{10}}$$

Where C = a constant varying according to design, usual values being 0.15 to 0.50.

D = diameter of fan in ft.

N = revolutions per minute.

STATEMENT OF OWNERSHIP, MANAGEMENT, ETC., OF
The Blast Furnace and Steel Plant

[Required by Act of Congress of August 24, 1912]

Name of Publication: The Blast Furnace and Steel Plant, published monthly at Pittsburgh, Pa. [Report for October, 1923.]

Publisher—The Andresen Co., Inc., 108 Smithfield St., Pittsburgh, Pa.
Editor—F. J. Crolius, 108 Smithfield St., Pittsburgh, Pa.
Managing Editor—L. L. Carson, 108 Smithfield St., Pittsburgh, Pa.
Business Manager—L. L. Carson, 108 Smithfield St., Pittsburgh, Pa.

Names and addresses of stockholders holding 1 per cent or more of total amount of stock:

L. L. Carson, 108 Smithfield St., Pittsburgh, Pa.
F. C. Andresen, 709 House Bldg., Pittsburgh, Pa.
C. J. Keller, 5840 Solway St., Pittsburgh, Pa.
R. H. Thiess, 426 Byrne Bldg., Los Angeles, Calif.
M. M. Zeder, 108 Smithfield St., Pittsburgh, Pa.

Known bondholders, mortgagees, and other security holders holding 1 per cent or more of total amount of bonds, mortgages, or other seurities: None.

L. L. Carson, Business Manager.

Sworn to and subscribed before me this 19th day of September, 1923.

CHAS. A. SEIBERT, Notary Public.

(My commission expires March 6, 1927.)

THE SAFETY CRUSADE

IMMEDIATE steps must be taken to prevent the ever increasing and appalling toll of human lives taken in the United States by avoidable accidents, Marcus A. Dow of New York City, president, told 3,500 delegates to the annual Safety Congress of the National Safety Council which convened in Buffalo Monday, October 1.

Accidents in 1922 claimed more than 75,000 lives in this country, Mr. Dow said. Over a period of 10 years, public accident deaths have increased out of all proportion, while in the same period industrial accident fatalities have decreased, he told the congress at its opening session.

Three thousand, five hundred men and women, representing the safety movement as practiced by the leading industries, railroads, and insurance companies of the country were in attendance at the congress.

"If there is any doubt in the minds of any as to the great need of organized safety work, just picture the far reaching and unhappy consequences of one single accident wherein the bread winner of one American family loses his life," he continued. Visualize what it means to that family to be suddenly deprived of a husband and father without warning of any kind. Picture the sorrow and heartbreak that is inflicted upon a happy family through the needless sacrifice of the life of a mother or a carefree, innocent child in an accident that ought never to have occurred. Then enlarge that picture by putting thousands of individual cases of family demoralization and suffering caused by thousands of accidents occurring in a single year and you have a picture of human suffering so pitiful, so appalling and yet so inexcusable that one can but wonder that the country has not taken steps before now to correct this evil.

"Every city contributes its quota of victims to the tragic and unnecessary evil that goes on day after day, week after week and that is increasing year after year in continental America largely through individual carelessness and lack of organized effort to eliminate accidents. It is bad enough that 75,000 persons of any age or station in life should be sacrificed on the altar of carelessness in a single year, but when we stop to consider that out of that number 20,000 were children under 15 years of age, of whom 10,000 were babies under 5 years, it is time for us to raise up and exclaim, 'This cannot go on. Let us get together and put a stop to it and wipe out this blot upon our nation.'

"Never have there been so many safety activities in the large communities as this year. There are now 50 organizations in as many cities in this country which are promoting the idea of safety among the people.

"Two million school children will receive education in accident prevention as a part of the regular public and parochial school curriculum during the year. Textbooks on the subject have been prepared with the help of the National Safety Council and will be used in the schools.

"The wonderful growth of the safety movement in this country has been because of the fact that the American business man possesses something greater than mere business intelligence. He possesses a heart. He possesses a soul. Encouraged by the success of accident prevention work in industrial plants, he has, in many cities, put his organizing ability and his intelligence to work in the laudable effort to prevent accidents outside of the industrial plant.

"The steam railroads of America have contributed significantly to the reduction of accidents through the safety section of the American Railway Association," Mr. Dow said.

"Our purpose is to save human lives. The consummation of 11 years in that direction has been the realization that each individual can save others from premature death and can prevent personal injury if he will conscientiously do the things we have together learned will bring about the maximum of safety.

"In this great stirring day of ours, when we have earned the value of so many things, we have been careless to some extent in acknowledging fundamental values. As we hurry along our crowded streets, as we hurry from our prolific factories, we should keep constantly in mind that there is one significant, intrinsic thing that gives value to it all. That thing is human life—the lives of our men and women, our boys and girls."

Insurance companies in this country are spending more money than all other agencies put together for encouraging improved working conditions in the nation's industries, it was asserted by Mr. Dow.

As president of the National Safety Council for the past year, Mr. Dow has directed the forces of that institution formed for the promotion of national accident prevention among the nation's millions in all walks of life.

The mobilization of all community forces through state and city safety councils to curb the mounting toll of public accidents, the training of children in schools in the fundamentals of street and home safety, and the drastic regulation of criminally reckless drivers for the protection of the great mass of careful motorists and pedestrians were urged by 3,000 members of the National Safety Council in a resolution adopted at the opening session of the twelfth National Safety Congress in Buffalo, N. Y., October 1.

The resolution reads as follows:

"Whereas, The 80,000 accidental deaths and millions of injuries occurring each year on our streets, in our industries, in homes and elsewhere are a blot on American civilization and the cause of untold suffering and sorrow, and

"Whereas, The direct economic cost of accidents involving personal injuries and deaths is estimated to run into billions of dollars annually, and

"Whereas, The safe and expeditious handling of street and highway traffic has become a most serious problem and the number of automobile fatalities is steadily increasing, and

"Whereas, Experience has demonstrated that at

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least 75 per cent of industrial accidents are preventable and the organized efforts of certain communities indicate that an equal reduction in public accidents is possible, therefore be it

"Resolved, That the National Safety Council in its twelfth annual congress assembled in Buffalo advocates:

"1. The adoption and strict enforcement of uniform, practicable laws and ordinances for the safeguarding of traffic and the protection of the multitude of law abiding drivers and pedestrians against the criminal recklessness of the few.

"2. The more careful study of our street and highway systems, both existing and projected, by competent engineering and traffic experts from the standpoint of safe and efficient traffic movement.

"3. The safeguarding of all dangerous machinery and places in industry and elsewhere according to standard methods of proved value.

"4. The development of industrial equipment and processes along lines of inherent safety for the double purpose of eliminating accident hazards and increasing production efficiency.

"5. The education of all workmen and their supervisors in safe methods and habits of work.

"6. The training in safety thinking of all school children, as well as students in colleges and universities, both for their own protection and as an object lesson in good citizenship.

"7. The mobilization of all community forces through state and city safety councils for securing these ends through the overwhelming force of enlightened public opinion."

The following directors were elected for three-year periods: Charles M. Anderson, Memphis, Tenn.; L. D. Burlingame, Providence, R. I.; L. A. DeBlois, Wilmington, Del.; H. W. Forster, Philadelphia, Pa.; Huston L. Gaddis, Grosse Ile, Mich.; Julien H. Harvey, Kansas City, Mo.; J. A. Cartel, Pittsburgh, Pa.; C. E. Pettibone, Boston, Mass.; Dr. A. D. Risteen, Hartford, Conn.; H. A. Rowe, New York, N. Y.

Program of Public Lectures at Carnegie Institute of Technology

Prominent European men of affairs, as well as distinguished American authorities, will be included in the program of public lectures for the present year at Carnegie Institute of Technology, Pittsburgh, says an announcement. According to the report from the institution, President Thomas S. Baker's policy of inviting internationally known leaders of science and letters for lectures will be largely extended to cover the program for the year.

Of outstanding interest in the announcement is the name of Dr. Nils Bohr, of the University of Copenhagen, and the winner of the Nobel Prize in Physics for 1922, who will lecture at Carnegie Tech some time in the latter part of November. Other speakers already engaged include Dexter S. Kimball, dean of the College of Engineering at Cornell University, for October 23, 24 and 25; Dr. John Erskine, professor of English at Columbia University, for November 19, 20 and 21, and Professor Albert Stansfield, of the Department of Metallurgical Engineering at McGill University, Montreal, Canada, who will lecture during the period between January 14 and 19, 1924.

Research Institute Proposed

A wide field of usefulness will be filled by the Institute of Research that it is proposed to establish in connection with Lehigh Universtiy, in the opinion of Lehigh alumni prominent in industry and engineering, assembled at Bethlehem, Pa., to take steps to broaden the usefulness of the university .

"An Institute of Research in connection with Lehigh University can be of especial benefit to Pennsylvania's industries," said Henry D. Wilson, president of the Wilson-Snyder Manufacturing Company of Pittsburgh, and president of the Lehigh Alumni Council that has just approved the plans of President Charles Russ Richards for Lehigh's expansion, including establishment of the Lehigh Institute of Research.

"There are innumerable opportunities for a Research Institute to discover new methods or appliances to improve industrial methods," Mr. Wilson said. "As an example, the development of our oil resources is limited by the depth to which we can drill. Anything that will improve methods of oil production at this time when we are finding the visible supply ahead limited, would be of especial value to the country. If some means could be found to increase the oil supply, it would be of tremendous value."

Curtis H. Veeder, president of the Veeder Mfg. Company of Hartford, Conn., said that an Institute of Research at Lehigh would be of incalculable benefit in improving production at the time when this country must enter keener competition with Europe.

"If Lehigh University through its Institute of Research could improve the methods used in the preparation of anthracite coal, it would be of great value," said Cadwallader Evans, Jr., a consulting engineer of Scranton, Pa. "If improved methods of combustion could be discovered, this would make possible more economical use of coal."

"An Institute of Research at Lehigh would fill a big gap," said Samuel T. Harleman of the Atlas Crucible Steel Company, Dunkirk, N. Y. "Although many corporations have research departments, their equipment is comparatively scanty and they lack the broad, thorough knowledge that a university would present. There is a big field for a research institute in trying out new inventions."

War Memorial Scholarships Announced

The winners of the four Westinghouse War Memorial Scholarships for 1923 have been announced. They are: George Earl Doty, of Pittsburgh, who will study electrical engineering at the University of Pittsburgh; Paul M. Williams, of Wilkinsburg, Pa., who will study electrical engineering at Carnegie Institute of Technology, and Lee P. Doyle, of San Francisco, who will go to Ohio State University for a course in electrical engineering.

The War Memorial Scholarships were established in 1919 as a means of perpetuating the memory of employes of the Westinghouse Electric & Manufacturing Company and its subsidiary companies who took part in the great World War. Each scholarship carries with it the annual payment of $500 for a period not to exceed four years, the payment to be applied toward an engineering education in any technical school or college selected by the successful candidates and approved by the scholarship committee. The scholarships are granted for one year only, but they will be continued for the full course provided the scholar maintains the academic and other standards required by the institution. Two classes of scholarships are provided: (a) for sons of employes of the company or its subsidiaries who have been employed for five years or longer, and (b) for employes who have been continuously employed for at least two years and who shall not on September 1 have exceded the age of 23.

SHEET AND TIN PLATE

Illinois Coal Meets Missouri Iron

The Final Link in the Chain of Complete "Ore to Sheet" Production Now Realized.

By F. J. CROLIUS

PART I

STEEL is now being produced at Granite City, Illinois, from raw materials assembled entirely from sources within a radius of 100 miles. That is a simple statement, but it carries much portent to the industry.

A glance at the accompanying radius map shows the relations between Iron Mountain, Missouri, and the coal fields of Illinois. It would be difficult to imagine a more strategic location for a great steel and iron center than this eastern shore of the Mississippi River directly opposite St. Louis, Mo. Fourteen different railroads serve the territory; the broad river furnishes an unfailing supply of constantly alkaline water for plant purposes, and remarkable water-transport, whose value in the production and distribution of heavy commodities is already recognized and highly developed.

The Govt. Barge Line handled 14,486,771 tons in 1922, and judged by the character of its service rendered, and the savings effected by its operation — will

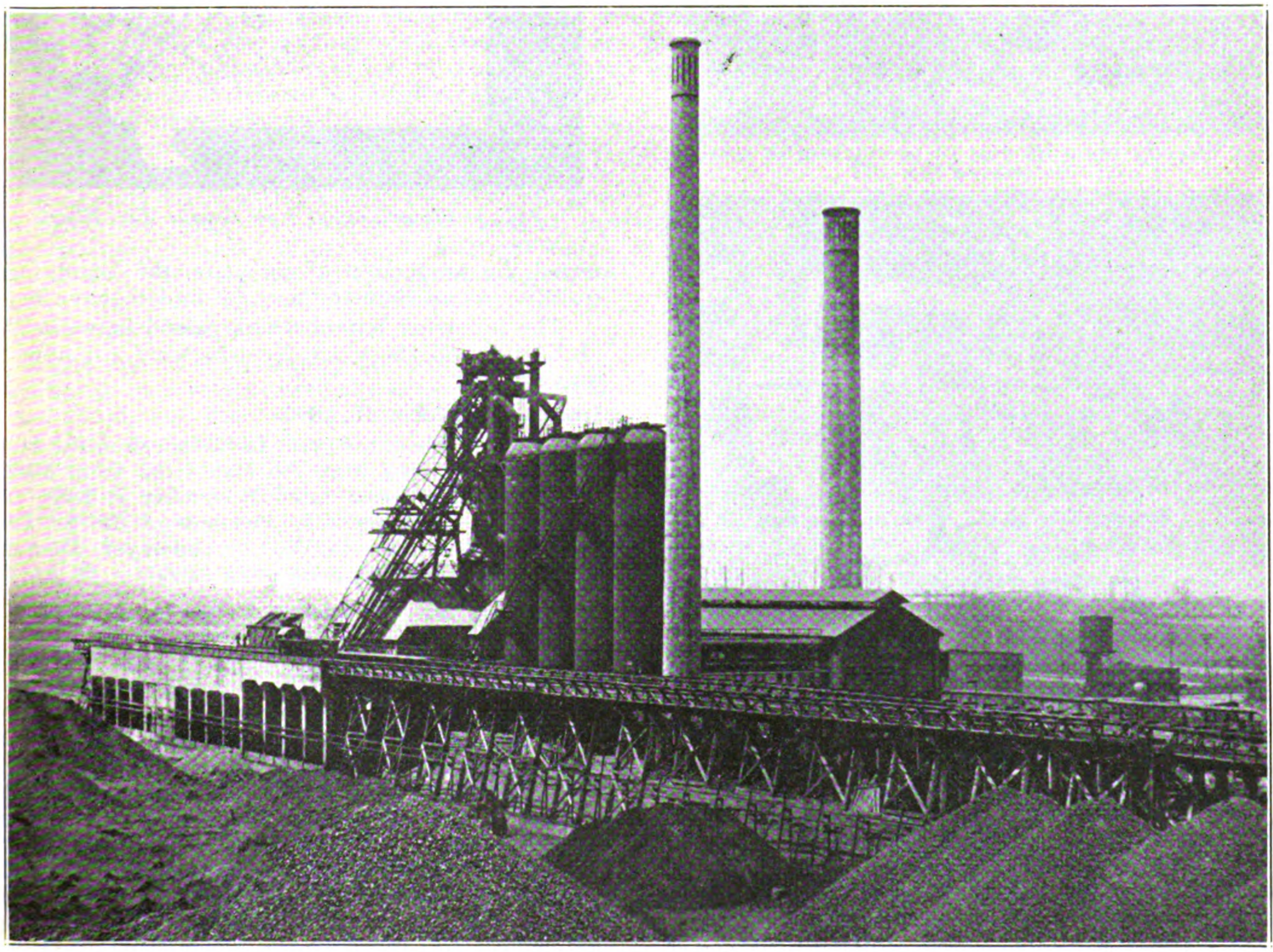

FIG. 1—*Recently completed blast furnace of the St. Louis Coke & Iron Company at Granite City, Ill. Iron Mountain ore is reduced with Illinois coke.*

continue to expand enormously. The physical characteristics of this level bottom land lend themselves ideally to great plant expansions—there is unrestricted room for the construction of any size or combination of buildings, and unlimited space for trackage facilities and yard storage. The plants at Granite City interconnect with 14 railroad systems through four different belt-line railroads.

Living conditions are excellent. East St. Louis is surrounded by fine farms, with soils that yield bounteously—a workman can own his own home and with little effort raise a large part of what his family needs—this ensures contented workmen, and an adequate labor supply.

In addition to coal and iron ore—the finest quality of lime stone abounds—and not of the least importance, clays for refractories. Missouri clays are distinctive in their inherent qualities of uniformity, ability to blend satisfactorily, and produce brick and tile which stand up under hard service. Ganister mined in the near vicinity of Granite City far surpasses in performance the silicas of other sections.

Practically all of the refractories used in these plants are produced at the very doors. What this means to a large steel operation can best be understood by executives who have lived through the recent sequence of mine and railroad strikes — when their very open hearth operation seemed dependent on local car movement.

It will be seen, therefore, that, the physical elements exist for a great production, and that facilities for distribution are in duplicate ratio. What about the market?

The radius of marketability of any product depends directly upon its cost of production in relation to the cost of production of similar products in other competing sections. Granite City enjoys a wider radius for competitive distribution than any other steel producing center, with the possible exception of Birmingham.

FIG. 2—*An instructive exhibit which assembles the products of Granite City.*

As we look to the west and southwest we see 40 per cent of all the railroad mileage in this country with that ceaseless demand for rails, cars, locomotives, etc., we see the vast petroleum industry calling for more miles of pipe—greater tankage—pumping facilities, we see the farms with those endless needs—the mines, etc. With this view in their minds' eye, the builders of Granite City have conceived and planned.

Behind the present completed producing units and those projected, lies the unique history of the men whose faith made it all possible.

The name Niedringhaus is synonomous with tinplate in America. When, in 1898, Wm. McKinley formulated the McKinley Tariff, which definitely protected the production of tin plate, the beginning of tin plate as an industry may be said to have begun.

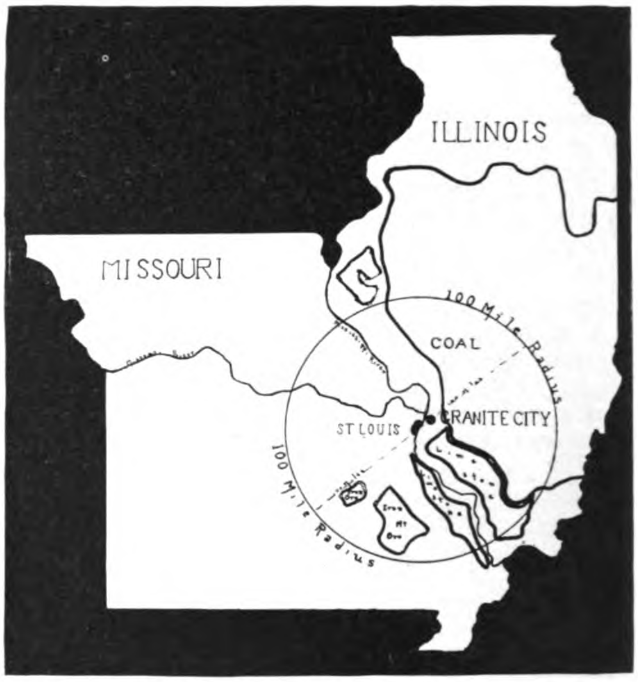

FIG. 3—100-*mile radius from Granite City, Illinois.*

The following letters which passed between Wm. McKinley and the elder Niedringhaus are now historical.

Iron Age, October 18, 1890.

In the course of his great tariff speech in the House of Representatives, May 7th last, Hon. Wm. McKinley, Jr., read a letter dated November 7, 1888, from Hon. F. G. Niedringhaus, president of the St. Louis Stamping Company, to W. C. Cronmeyer, Demmler, Pa., of which the following is an extract:

> Dear Sir: In answer to yours of the 22d instant, in reference to the manufacture of tin or terne plates, we are at liberty to state that one of our mills has already been arranged for tinplate work, and a sufficient duty is put on the article to cover the difference between the English and American scale of wages we will be ready to turn out plates on short notice. It is also very evident that in case a proper duty is fixed on tin and terne plates a large number of English manufacturers will move their works over to this side. The question as to whether these plates will be made in this country, therefore, depends solely upon proper legislation. We have for the last few years contemplated building an additional mill, but did not, under existing circumstances, consider the invest-

ment a safe one. This danger, however, is in a measure removed.

He also submitted another communication from the stamping company, written during the present year, which we print in full:

St. Louis Stamping Company,
St. Louis, February 14, 1890.

Dear Sir:

We received some days ago a number of sheets of tin-plate which you claim were made at the experimental plant at the Pittsburgh exposition last fall. In reference to same we beg to say that we have made up two or three articles in stamped ware out of the plates sent us. We now desire to say that we find the plate equal to the work, and the quality and finish of the goods every bit as good, if not better, than plates we are now regularly importing from England for similar work.

Yours very truly,
St. Louis Stamping Company,
Thos. K. Niedringhaus, Sec.

W. C. Cronemeyer, Esq.,
Secretary American Tin Plate Association,
Pittsburgh, Pa.

The publicity thus given the stamping company's views on tin-plate manufacture was undoubtedly of great help in so shaping legislation as to encourage the establishment of the industry in this country. It was made evident to the reading public that there was no great mystery to be pierced nor no huge obstacle to be overcome by American manufacturers before the production of tin-plates could be successfully entered upon in the United States. The only difficulty in the way, manifestly was the opposition to such an increase of duty on imports of tin-plate as would protect American wages in the business against the cheaper wages abroad. With wage conditions equalized, it was seen that American manufacturers in number were ready and willing to invest ample capital in the proposed new industry.

In the case of the stamping company particularly, the letter of its president excited much comment locally and throughout the country. It was interpreted to mean that the company had a well-matured idea of establishing the new industry in this city if the duty on imported plate provided for in the McKinley bill should become law. Among those more or less familiar with the affairs of the great concern, it was regarded as a formal announcement of business intentions.

In a most interesting address recently, Mr. George W. Niedringhaus, son of the Hon. F. G. Niedringhaus, drew a picture of Granite City, present and future, which will bear repeating:

"Coal is the shortest word we have to express industrial power and domestic comfort. There is no city in the world which has so much coal lying at its door as St. Louis.

Illinois coals have erroneously been considered "non-coking," due to the many fruitless attempts made to coke them usually as a partial mixture with the so-called "coking" coals of the East and South, and, until the Roberts process was invented never coked successfully into a metallurgical product.

Mr. Arthur Roberts' experiments began some 15 years ago, and he was ably assisted in his engineering work by Mr. M. W. Ditto, who has been associated with him for the past 10 years. The installation at Granite City consists of 80 Roberts ovens, capable of handling 2,000 tons of coal in 24 hours, with a blast furnace of approximately 500 tons capacity, completed early in January, 1921. The first coke made was on January 8th of that year, and the ovens have been running continuously since that time.

Mr. Brassert, one of the foremost Blast Furnace engineers in the world and for many years associated with the U. S. Steel Corporation, designed the furnace at Granite City. He was very skeptical of the use of a metallurgical coke made out of Illinois coals, and in order to satisfy his firm we purchased a large tonnage of Connellsville coke made out of the low volatile coals of Pennsylvania for the initial starting of the Blast Furnace. As the blast furnace was not blown in until three weeks after the starting of the coke ovens, and further as the result obtained out of the Illinois coals in the Roberts ovens was so very satisfactory, Mr. Brassert and his engineers gave their consent to the using of the Roberts coke exclusively on the blast furnace. So not a pound of Connellsville coke ever has been used; in fact, no coke has ever been used on the blast furnace except that made in the Roberts ovens at the Granite City plant.

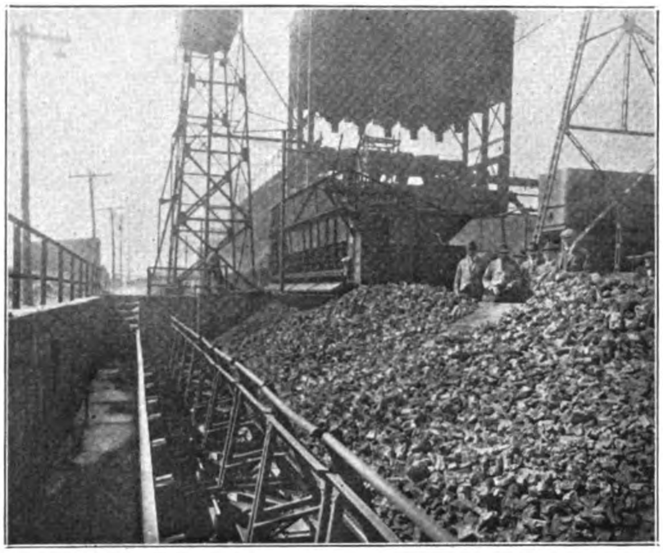

FIG. 4—*Unloading coke cars.*

We have made interesting records, not only in the short coking time, but also in the low consumption of coke per ton of pig iron on our blast furnace. As the National Enameling & Stamping Company have been large users of the product of the blast furnace, I repeat a statement made to me by our superintendent, "that is the finest and best analysis in pig iron that the National has received in the past 15 years."

The St. Louis Industrial District, now that the coking of the Illinois coals has been conclusively demonstrated, has greater natural advantages, with a greater abundance of raw materials at its doors than any similar situation for the development of iron and steel in the United States. We can draw all of our supplies for the making of pig iron from within a radius of 125 miles of St. Louis. While Missouri ores have not been thoroughly developed, due to a lack

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of demand, still the demand which is here and will become greater will bring about this development. In addition to the coal and ores, we have lime rock within eight miles of St. Louis, equal to any in the country.

St. Louis was an iron center long before Pittsburgh began its development in this industry, and ores from the Iron Mountain mines in Missouri were transported by wagon for a distance of 48 miles to Ste. Genevieve on the Mississippi River and hauled by barge to Pittsburgh. If I remember correctly, James Gayley, mentioned by Mr. Carnegie in his memoirs, was originally in charge of the old blast furnace in South St. Louis. With the development of the beehive coking in coal near Pittsburgh, James Gayley was employed by Mr. Carnegie to assume charge of the small blast furnace in the Pennsylvania city. Had the coking of Illinois coals been developed at that time, St. Louis today, would be one of the big steel centers of the country.

Mr. James J. Hill, that masterful man of the Northwest some 30 years ago told my father, while on a visit here, that St. Louis was the natural meeting place of the Northern ore and possibly the Illinois coals, that a method would be discovered and invented to coke these coals. However, he overlooked the possibility of Missouri ores, which I feel confident will play an important part in the St. Louis development.

Illinois has millions of tons of coal—an inexhaustible supply. In the year 1920, 19 per cent of the coal mined in the U. S. was mined in the State of Illinois. The impression has prevailed that only 5 per cent of all the coal supply in the U. S., located largely in Pennsylvania, West Virginia, and a few of the Southern States, could be utilized in by-product ovens. The Roberts process has made it possible to coke over 45 per cent of the known available supply. It may interest you, also, to know that during the past year we have coked upward of 42 different grades of the Illinois coals.

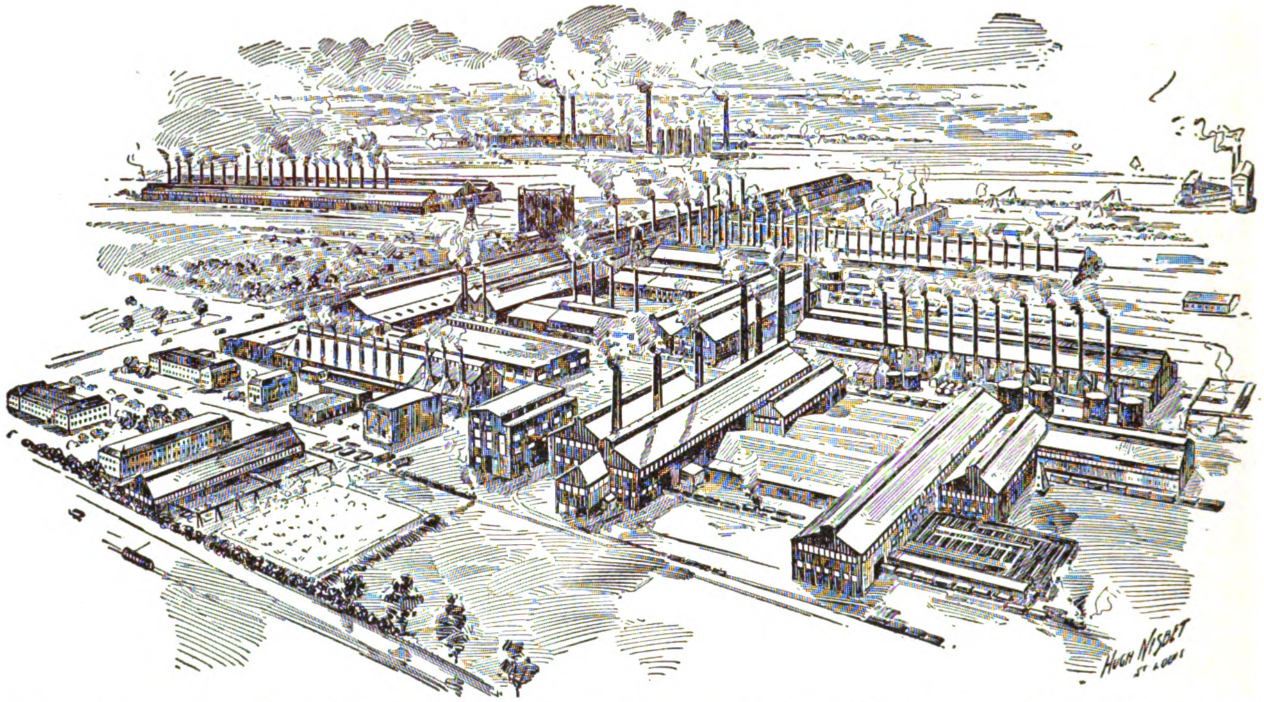


FIG. 5—*Present plant of National Enameling & Stamping Company showing blast furnaces and coke ovens, and sheet mills in background.*

Cheapest Place to Make Iron.

To assemble the five tons of material necessary to make a ton of iron costs, for freight alone, at—

Chicago (Gary)	$8.89
Pittsburgh	8.59
St. Louis—	
All Northern ore	.784
20 per cent Missouri ore	7.33
50 per cent Missouri ore	5.82

32 per cent less than Pittsburgh; 35 per cent less than Chicago.

The cost of transportation is another great advantage for the St. Louis Industrial District. Taking figures from the Iron Trade Review of July 1, 1922, they show that the freight charge on all the raw materials which go to make up a ton of pig iron in the Pittsburgh district amounts to $8.59. This charge in 1913 was $4.95. These charges do not take into consideration the labor in producing the raw materials, royalties, etc. The freight charge on assembling materials for a ton of pig iron in the St. Louis industrial district, using all Northern ores is $7.84. The freight charge on the material for a ton of pig iron in the Chicago district, with all Northern ores, is $8.89. Using as we are at the present time in Granite City, 20 per cent of Missouri ores and 80 per cent Northern ores, the charge is $7.33, or if 50 per cent of Northern ores are used and 50 per cent Missouri ores, the freight charge will be $5.82, so the advantage over Pittsburgh and also Chicago is very apparent.

A survey of the tonnage in pig iron consumed in this district during a normal year shows that it amounts to approximately 750,000 tons. Heretofore this pig iron was shipped largely from Birmingham, Ala., and the Chicago district. The development of the large steel foundries, and also steel plants here has been remarkable. I presume few realize that Granite City in normal times has a steel production of over

2,000 tons daily, which requires 800 to 1000 tons of pig iron.

Other plants in St. Louis, East St. Louis and Alton will require an additional 1500 tons. This will even be increased on the completion of the new additional sheet capacity and the 100-inch Tandem Plate Mill now under construction for the National Enameling & Stamping Company in Granite City, which will materially add to the pig iron consumption of the National Enameling & Stamping Company.

I will mention two industries that have recently decided to locate here, and credit is due to the development of the coking process at Granite City. The most important is the American Locomotive Company with plants located throughout the east at the present time. After an exhaustive investigation they decided to purchase 200 acres in Granite City within a short distance of the plant of the St. Louis Coke & Chemical Company, and have plans drawn to construct a plant at an approximate cost of $15,000,000, with a capacity of finishing 150 locomotives a month. They have decided to abandon their plants at Pittsburgh and Paterson, N. J., using this large new unit at Granite City for the western trade.

According to Mr. Fletcher, their president, the freight saving in assembling a Santa Fe engine weighing 395,000 pounds at St. Louis was $1,205 per engine, and, the freight saving on a Mallet engine weighing 465,000 pounds was upward of $1,500. Furthermore, he stated that the railroads operating out of St. Louis used over 40 per cent of the country's locomotives. In other words, four out of every 10 locomotives in service in the U. S. railroads could purchase their engines in St. Louis and make delivery to destination entirely on their own tracks.

It is, also, interesting to learn that of a modern locomotive of the type built by the American Locomotive Company 85 per cent of the material such as plates, steel and brass castings, wheels, sheets and brakes, can be produced in the St. Louis district, and the production of the remaining material will follow.

Another industry that has come to this district is the F. J. Lewis Manufacturing Company. Their decision to come came about in a peculiar way after their president, Mr. F. J. Lewis, had made an investigation of the distributing advantages of this location.

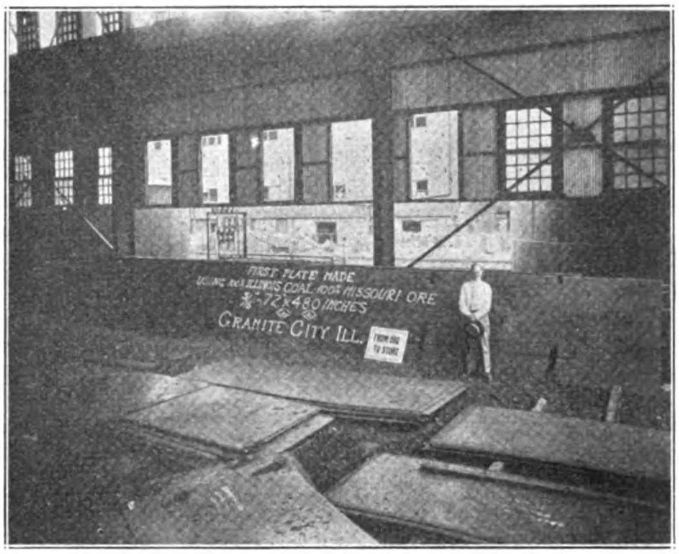
As you know, a by-product of the coking of coals is ammonium-sulphate, largely used for agricultural purposes, and in the artificial production of ice. Mr. Lewis had a Japanese order for 2,000 tons of sulphate, which he expected to ship overland via San Francisco; any my suggestion to him that he see what rate he could procure via barge line on the Mississippi prompted him to make an investigation, which resulted in a saving of $5.00 per ton in the freight charge via river, New Orleans to Japan, over the San Francisco route. This impressed him so, that he decided to build a plant at Granite City to cost eventually a million dollars for the distillation of tar.

Mr. Lewis has, also, told me that the possibilities of the river, which will enable him to have cheaper rates to the seaboard for export; also, the advantages of this location in the center of the country with the freight rates in favor of distributing his products at the lowest cost will eventually make his development here greater than his plants in Chicago and Birmingham.

Other industries must follow.

Statements have been made by enthusiasts of the steel and iron possibilities of this district—and I am one of them—that in the next 25 years, the St. Louis district will be a greater steel producing center than Pittsburgh today. We have the coal at our doors, we have iron ore close by, as well as lime rock; and to complete the situation—great advantages in freight, distributing over a district bounded by the Gulf of Mexico, as far West as Denver, and into the Northwest as well as the great agriculture state in the Mississippi Valley.

So let us look forward to greater steel mills, eventually producing rails, steel pipe for the great oil fields in the South and West, wire and nails, structural steel, and the many kindred products of steel.



Mr. Niedringhaus and the first plate.

Mr. Paul W. Brown, editor of "America at Work" and closely associated with all things St. Louisan analyzes industry into its statistical elements and becomes even more enthusiastic than Mr. Niedringhaus.

"The Strategy of Steel," published in June of this year, created much comment.

The strategy of modern industry is the strategy of steel. This takes on enormous importance when we stop to consider the fact that the foundation of our present civilization is industrial. Other civilizations have had other springs, but "for this day and date," as the railroad tickets say, the form of organization of human society is centered on man's efforts to get a living. The French Revolution was political; the Russian Revolution a century and a quarter later was economic. The nations engaged in the late war were each other's equals in valor, and a layman can see no essential difference in military skill; it was the steel works of the United States and of England which so far overshadowed the steel industry of Germany that they won the war. The English blockade which cut off the German supplies of such necessaries as food and rubber and copper was literally a ring of steel—the potential military strength of modern nations may be exactly estimated by the number of pounds of steel produced per year per capita.

What the Age of Steel Means.

Why is this the Age of Steel? The explanation is a very simple one and we do not have to indulge in the rhetoric which the steel industry, through no effort of its own, seems to evoke from many writers in order to understand why. Up till the beginning of the Nineteenth Century the sole force in the industrial world was the power of men and horses with some incidental reinforcement in special activities such as the grinding of grain and the pumping of water, from water wheels and windmills. The world's machines were chiefly driven by the hand or foot. The hand loom wove the cloth and the foot power lathe shaped the wood or metal. About the time of the American Revolution, however, James Watt invented the steam engine. This revolutionary contrivance began to make itself felt in a large way about 50 years later; its real making over of society is not much more than three decades old.

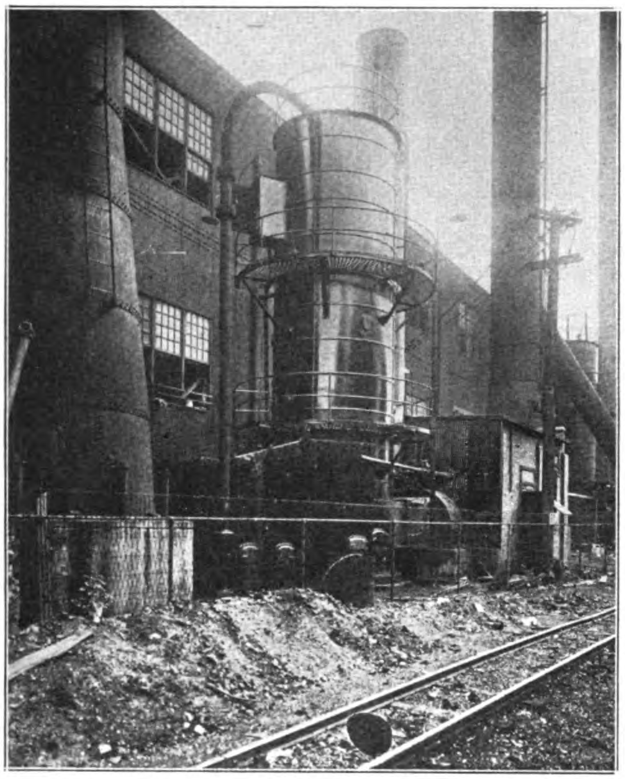


FIG. 7—*Waste heats from open-hearth furnaces are recovered through vertical water tube boilers.*

More Power per Man.

In the Manufacturers' Census taken just prior to the Census of 1870, there were reported in the shops and factories of the United States, engines, water wheels, etc., with a total capacity of 2,346,000 hp. In the half century which has elapsed since that time, the population of the United States has increased one and two-thirds times, but the number of hp. of machinery in our shops increased 11 and one-third times. In other words, there is over four and one-half times as much power serving the needs of each citizen of the United States in manufacturing alone as there was a half century ago.

The steam engine is primarily a device for the use of stored sun power of long past ages, whether it burn coal or oil; the internal combustion engine, whether running on oil or liquids distilled from coal, taps the same reservoir. We have not yet learned how to use the enormous present power of the sun in the industrial service of man, except by water power, but the fierce sunlight of the Carboniferous Age stored up for us in the world's coal and oil, is today firing our boilers and turning our wheels. It has been estimated that one hp.—a mechanical hp., by the way, is far greater than the energy of an average horse — is equivalent to the energy of 18 men. If this be true, the 26,000,000 horsepower impelling the machinery in the shops and factories of the United States is equivalent to the labor of a working force of 468,000,000 men. Of course this rough comparison is much more economically and effectively applied than human energy ever was. But this comparison serves to show us the material advance of the Age of Steel over all other ages.

Eight Hundred Million Men.

So far we have been considering merely the hp. employed in labor. Last year the United States Geological Survey issued a world atlas of water power. There the energy of all the stationary engines and water wheels of the United States employed in manufacturing, mining, transportation and public utilities is estimated as 49,000,000 hp. The people of the United States, therefore, have not only energy ready to hand at our factories equivalent to that of 468,000,000 human beings; they have the equivalent of the energy of 414,000,000 human beings more in engines and water wheels devoted to other services. This makes 882,000,000 manpower. Add to this the hp. of locomotives and motor vehicles and it will be seen that the 105,000,000 inhabitants of the United States (1920 census) are served by an energy equivalent to that of more than a billion men.

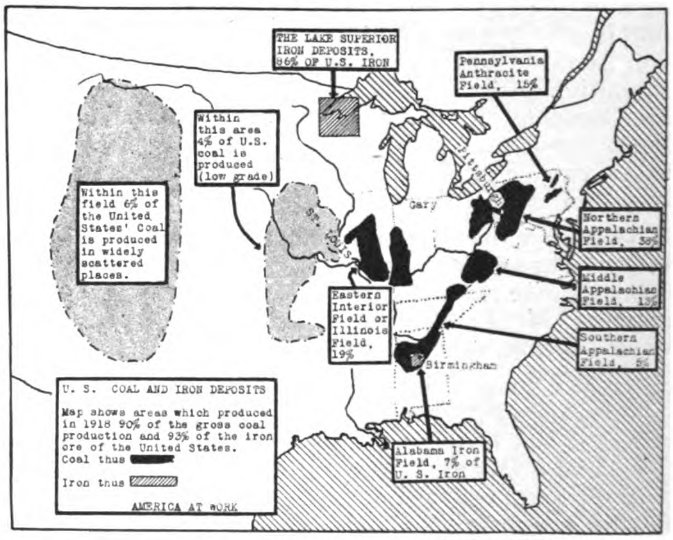

THE LAKE SUPERIOR IRON DEPOSITS, 86% OF U.S. IRON
Pennsylvania Anthracite Field, 15%
Within this area 4% of U.S. coal is produced (low grade)
Within this field 6% of the United States' Coal is produced in widely scattered places.
ST. LOUIS
Gary
Pittsburgh
Northern Appalachian Field, 38%
Middle Appalachian Field, 13%
Eastern Interior Field or Illinois Field, 19%
Southern Appalachian Field, 5%
Birmingham
Alabama Iron Field, 7% of U. S. Iron
U. S. COAL AND IRON DEPOSITS
Map shows areas which produced in 1918 90% of the gross coal production and 93% of the iron ore of the United States.
Coal thus
Iron thus
AMERICA AT WORK

FIG. 8—*Geographical distribution of iron ore deposits.*

This is a change which has come upon us so quickly that we have not even begun in our bewilderment to appreciate its full significance. Perhaps the imaginative literature of the past will help us more than the sober histories. In the time of Queen Elizabeth, the poet Marlowe wrote his great drama of Dr. Faustus, and he represents Faustus as selling his soul for the acquisition of certain powers. He flies through the air; he presents the wives of noblemen with grapes and other rare fruits in winter; he brings tidings from afar in an instant of time. Today the airplane is a common sight; fruits out of season appear as a matter of course on the tables and in the lunch pails of the rank and file of American workmen; through the telephone and the radiophone, not only news but the inflections of human speech and the peculiar timbre of the voices of singers may be conveyed through empty space over thousands of miles.

Back of all this is the steam engine. It is the parent invention of all other inventions.

Steel Made This Possible.

Without steel, the steam engine would have become little more than a laboratory plaything. It requires a material of enormous strength and uniform texture—a material which is a good conductor of heat, but which is absolutely resistant to fire. Steel is such a material. No metal other than iron, possessing the necessary strength, toughness and conductivity, exists in sufficient quantities in the earth's crust to serve the needs of a Power Driven Age. It is this which has drawn a broad line of demarcation between the material civilization of all ages previous to 1800 and that of our own. It is this which has placed the luxuries of kinds on the table of the hodcarriers. This change is today abolishing menial service in the homes of the land and making it possible for people of culture and personal energy, reinforced by modern machanical appliances, to perform all the work of their homes and still have leisure for travel, study and recreation.

Let us look at the geography of the Age of Steel. (The accompanying map is founded on the Mineral Production Section of the United States Geological Survey's incomparable World Atlas of Commercial Geography.)

During the generation which ended with 1914 the three strongest nations in the world from the economic point of view were the United States, Great Britain and Germany. These are precisely the three nations of the world possessing the greatest reserves of coal. The United States was the largest producer, with Great Britain next, and Germany third. France, with about one-fourth Germany's coal production and —Lorraine being in the hands of Germany — two-thirds her iron resources, was weaker economically in just about the proportion of her command of fuel for primary power. Austria's small coal and iron reserves were reflected in her relatively unimportant economic position, while Sweden and Spain, compelled to ship rich iron ores out of the country for lack of fuel wherewith to smelt them, were but minor provinces on the boundary of the Empire of King Steel.

When we look at the map of the United States we see spread out before us the domain of King Steel. Roughly shaped like a great fish, its nose almost touching the southern boundary of New York and its tail almost touching the eastern boundary of Mississippi 700 miles to the southwest, lie the Appalachian coal fields. Certain outlying deposits to the east are easily accessible from the Atlantic seaboard. On the northwest, it is but a few miles from the Pittsburgh and Mahoning Valley deposits to the thousand-mile inland deep waterway of the Great Lakes. In Southern Illinois and Indiana and Western Kentucky lies the great Eastern Interior field, with one-fifth of the coal reserves of the country. More than nine-tenths of the country's iron resources are in two great deposits at the head of the Great Lakes and in the Birmingham district. Fifteen per cent of the country's coal resources are found near the Atlantic seaboard in the wonderful anthracite district of Pennsylvania. The strategy of American industrial development is summed up in these few simple facts so clearly shown by the accompanying map. The greatness of the Atlantic seaboard cities, the enormous concentration of industrial power in the Pittsburgh district, the "beastly prosperity" of the growing metropolises of the Great Lakes and the incomparable position of St. Louis and the surrounding industrial cities of the Mississippi Valley, all may be characterized in terms of the geography of the Empire of King Steel. Half the known resources of coal and iron in the whole world are to be found in the United States.

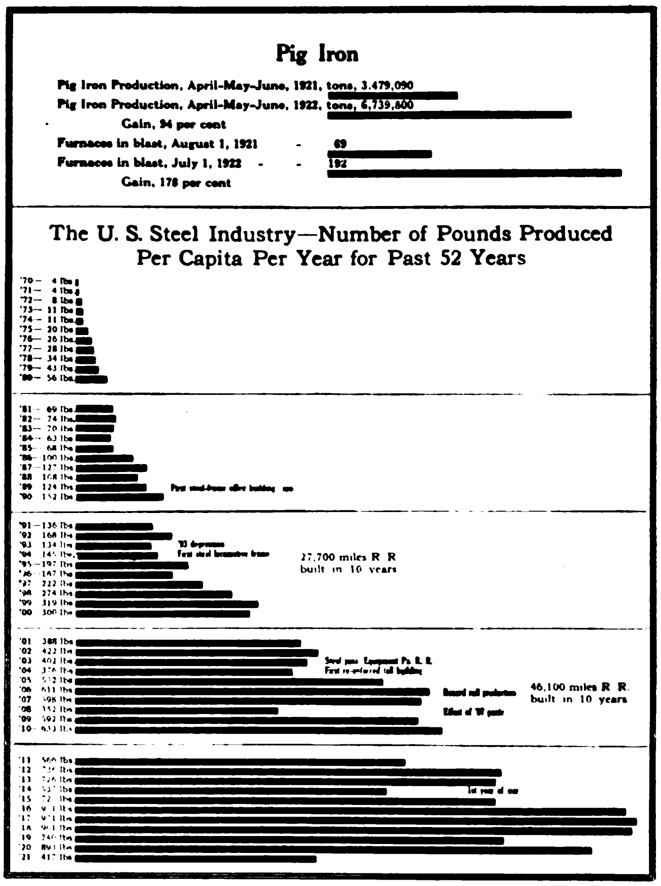


FIG. 9—*Remarkable increase in per capita production of steel.*

In a later article, "America at Work," describes the rejuvenation of Missouri ore mining as a tonnage factor.

(To be continued.)

The November and December issues of this magazine will contain a continuation of the story of National Enameling & Stamping. From the most modest of beginnings, with only a small stamping press, designed by its founder, the organization has expanded to world-wide proportions—its familiar trademark has become a household necessity. The Granite City plant alone includes by-product coke ovens, blast furnace, open hearths, bar mills, plate mills, and the most modern sheet mills just being completed by the United Engineering & Foundry Company and put in operation. The historical Iron Mountain ore mines will be described in detail.

Annealing of Sheet Metal for Stamping

Minimum Grain Growth and Removal of Rolling Strains Are Very Important to Users of Sheet Metal for Stamping—Temperature Curves and Stamping Tests Discussed

By FRANCIS G. WHITE†

PART I

GENERALLY speaking the requisites necessary for the successful annealing of sheet steel are, minimum grain growth, the removal of rolling strains, case of opening after annealing, and a clear surface on the sheet. The cost of obtaining these qualities must of course be no higher than the trade will stand. To the user of sheet metal for stampings, the annealing is very important. While tin plate is not ordinarily thought of as a stamping steel, tin cans require double seaming, while the tops and bottoms are light stampings. Galvanized sheets are very seldom stamped except when tite coated, but the trade seems to require a soft sheet whether it is blue, black, galvanized or tinned.

The various types of annealing furnaces, fuels, and methods of handling sheets and boxes are discussed. Certain annealing tests conducted by the author involving furnace design, fuels, etc., are incorporated in the text of this paper.

Box Annealing Furnaces

The fuels used may be either oil, gas, coal or electricity, while the furnace type may be the box, continuous box, or the continuous muffle. A furnace is usually built for one certain fuel, but probably with some rearrangement it could be adapted to more than one. The newer continuous box type furnaces are more or less in the experimental stage although numerous installations are giving great success. The old box types are the more common and are fired by either oil, gas, or coal. The first two of these fuels have a tendency to burn the sheets rather than anneal them, and the number of stickers is quite liable to be more pronounced. Two types of box furnaces are shown in Figs. 1 and 2, and after a trial on oil and gas were finally fired with coal screenings through automatic stokers, with fairly good success.

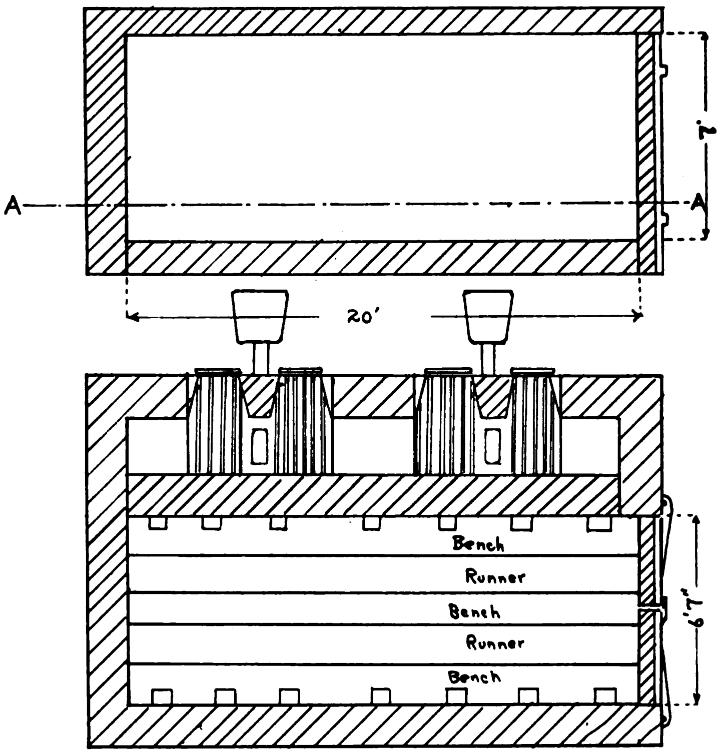


FIG. 1—*Side-fired double stoker box type annealing furnace. Lower sketch is Section AA showing flues. Upper sketch half longitudinal section.*

Fig. 1, is a side-fired furnace while Fig. 2 is rear-fired. The problem of heat distribution within these furnaces had to be carefully studied before any set annealing practice could be followed. Sliding dampers on the flues, flues of various sizes, the height of the bridge wall varied, a recuperative bridge built, and the benches redesigned to allow the circulation of draft below the box, were some of the variables encountered. Most of the tests described in this paper were run using one certain sized bottom and cover as shown in Fig. 3, with four such boxes charged into each furnace.

In the furnaces described, it was customary to pile the sheets as high as the cover would allow, this being about 42 inches, making the weight of sheets in each box vary from 10,000 to 16,000 lbs., depending of course on the size of the sheets. On first thought it would appear that a uniform temperature throughout the furnace would be ideal, but when it comes to annealing many different sizes of sheets, a nonuniformity is at times advantageous because a heavy box of large sheets could be placed in the hottest portion of the furnace and the lighter boxes nearer the door. The actual practice, involving temperature and time will be discussed later in this paper under the heading of the various grades of steel, such as tin plate, deep stamping metal, etc.

Pyrometric equipment was installed, two thermocouples in the side-fired furnaces and one in the rear-fired. Rare metal couples were used and an indicting instrument for the operator with recording instruments in the superintendent's office were supplied. It must be remembered that these instruments merely give the roof temperature of the gases and not the temperature of the steel within the box. The relation of the temperature of the steel to the roof temperature was carfully determined on several hundred boxes. In this annealing, the time element was found to be an important factor to be considered, because the air space within the cover is a very poor conductor of heat. To obtain the actual temperatures within the boxes by pyrometers requires quite an added expense on routine work so that when a set practice was adopted this equipment was no longer used. By observing the roof temperature reading, and applying the time factor, a fairly accurate figure for the temperature within the box could be estimated. Fig. 4 shows the arrangement of the thermocouples as they were set within the boxes. Iron constantan couples were made up, each wire being covered with clay insulators, and the temperature read with a potentiometer type pyrometer. The longest couples were about 30 feet, being used on the back boxes, while the others were shorter. In packing the sheets two ⅝-inch sheet bars were placed in the pile one or two inches apart, the bottom ones about 10 inches from the bottom and the top ones a similar distance from the top. By inserting the couple so that the junction was in the middle of the pile, then leading the couple under the cover and piling sand around the bottom, an air seal was effected. The boxes were then run into the furnace and the couples were lead out under the door, where they were connected to a multiple point switch, so that the reading time was quite rapid. Ordinarily, the reading was stopped when the temperature on all couples began to fall, which was often several hours after the boxes had been removed from the furnace. These thermocouples rarely lasted over five heats, so for regular practice the expense was far too great.

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*A paper to be presented at the annual convention of the American Society for Steel Treating, Pittsburgh, October 8-12, 1923.

†Metallurgical Engineer, National Enameling & Stamping Company, Granite City Steel Works Branch, Granite City, Ill.

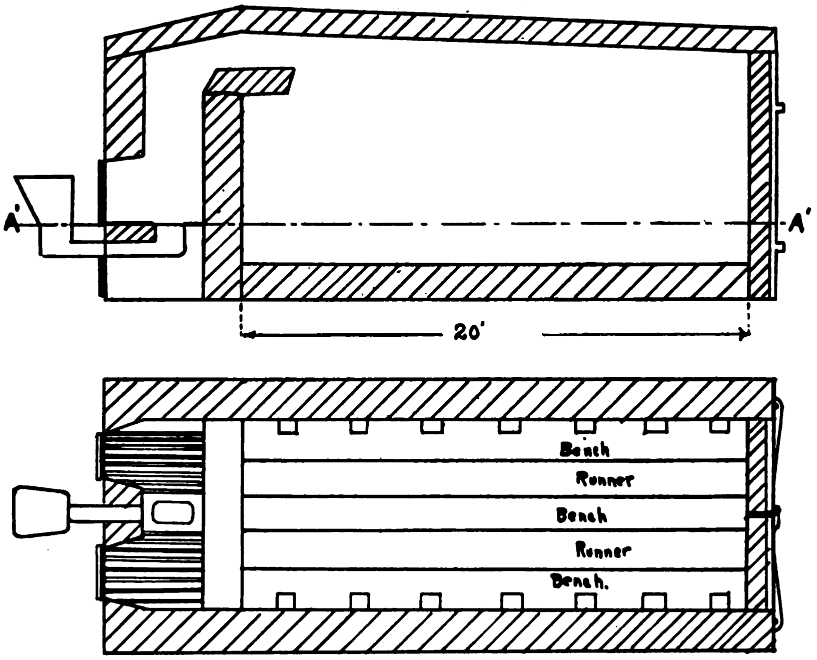


FIG. 2—*Rear-fired single stoker box type annealing furnace. Lower sketch is Section A'A', showing flues. Upper sketch half longitudinal section.*

On several occasions there was a decided rise in the temperature readings several hours after the boxes had been removed from the furnace and at a time when the temperature curve showed a uniform drop for several hours. This may be a new critical range and always occurred around 900 deg. F. No further discussion of this peculiar action will be taken up in this paper, because the author has not enough data at hand to say much about it. This condition may look like a pyrometric misreading, as there seemed no justified cause for it. While speaking of temperature readings it might be well to say, that in all this work the cold end was compensated by junction boxes in small wells surrounded by circulating water under a constant temperature of 5 deg. F., and for roof temperature work rare metal couples were used. While pyrometers, without a doubt, are very helpful to both the annealer and the superintendent, who can thereby check his work, there is nothing more harmful to "the man at the fire" than an inaccurate or unreliable instrument.

Furnace Charging Methods.

Concerning the methods of charging box annealing furnaces, two types might be considered. The cannon ball type, where the bottom is placed on several iron balls of about eight inches in diameter, has a great advantage, inasmuch as it allows a greater circulation of heat around or beneath the box. When benches are used, the boxes are placed on a jack or charging machine and pulled or pushed into the furnace. Here the bottoms are supported in many places and warping is less common. The bottoms are cast with fins which allow some circulation beneath them.

Continuous Box-annealing Furnace.

Undoubtedly the continuous furnace has some advantages over the stationary type, but there is still the necessity of expending a great deal of heat in heating the cover and bottom. At times this dead weight may exceed the weight of the sheets themselves. In this type of furnace the box is placed on a continuous belt or chain and carried through the furnace. By varying the speed of the chain a somewhat better control of heat is obtained over the stationary type of furnace.

Continuous Annealing In Muffle Without Boxes.

While the author does not know of anyone using

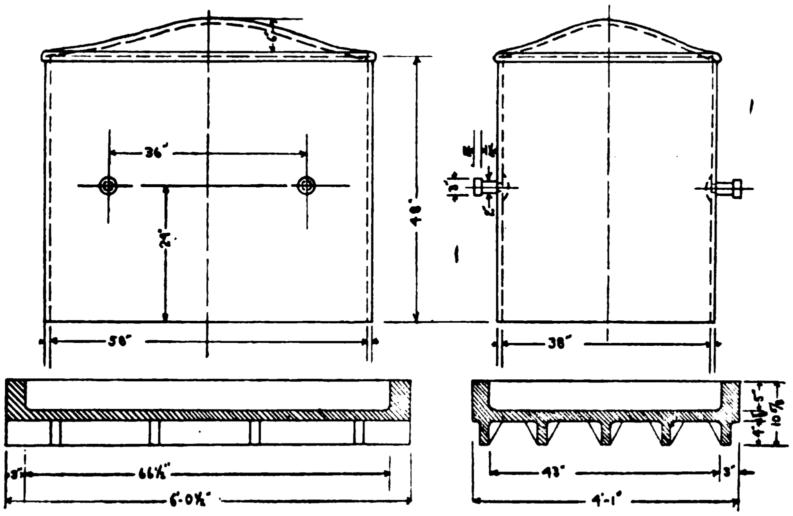


FIG. 3—*Small size annealing cover and bottom cover weight—3300 lbs. Bottom weight—3250 lbs.*

a continuous muffle furnace, without the use of covers or boxes, and in which is maintained a reducing atmosphere, nevertheless such a furnace has many commercial possibilities. Fig. 5 shows the plan and elevation of such a furnace. It would eliminate the heating of bottoms and covers and except for the continuous chain and the furnace losses, all the heat expended would go directly into the material to be annealed. The sheets could be piled a few inches high, instead of forty or fifty as is common, thereby enabling the material to pass through the heating zone rapidly, and cutting the annealing time from approximately sixteen hours to an hour or two, or perhaps less. The temperature at which the sheets would stick could be obtained and then the furnace temperature not allowed to run over it.

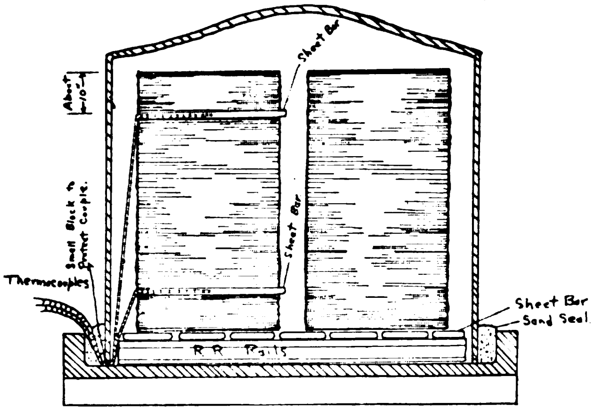


FIG. 4—*Cross section of annealing box showing method and position of inserting thermocouples.*

Stamping Qualities of Steets.

In box work, it is quite necessary to have an air-tight cover inasmuch as a leaky one will produce red or black sheets, burnt edges, or dirty surface. Lifting a cover too soon will give somewhat the same effect, and numerous customers believe that a sheet with well blued edges is a sign that it has been well annealed, while in reality every box of steel could have a blue edge if it were allowed to get the air too soon.

Steel sheets are frequently deoxidized in annealing, i. e., annealed in a box in which the entrapped air is displaced by a non-oxidizing gas—and the resulting sheets are silvery white, with no trace of scale on them. Such a furnace as described would merely make the muffle an annealing cover, and since the cover method will work satisfactorily, the installation of a conveyer in a muffle is only a matter of mechanical arrangement. The blue annealing in an open furnace is a good example of rapid annealing, and on tests on similar gage box-annealed, the blue annealed sheets were much softer and stamped better.

Before taking up the furnace curves and actual temperatures used in these tests, the stamping qualities of sheets will be considered. White softness is usually the quality referred to, it seems an inaccurate way of expressing the stamping qualities, for an over-annealed sheet, exhibiting a large grain structure, will be dead soft if tested with any type of hardness tester, and a rough sheet will usually test softer than a highly polished one. The Erichsen testing machine, which seems to be the adopted standard for stamping tests, will show the stamping qualities quite clearly. In operation this machine holds a strip or square of about three inches in width, tightly against a die which has a circular opening in it which is approximately one inch in diameter. A rounded plunger on a screw is tightened up against the sheet and when a crack appears, the depth of impression is read on a gage. The relation of the sheet thickness and the depth of impression can be compared to a standard curve and expressed in percentage of the standard. If we cut a diagonal across a sheet and take five or seven readings across this diagonal, and then find that the highest readings are near the edges, then we can say that the sheet is under-annealed, because the heat has not had time to penetrate to the middle of the pack. If the middle test gives the highest reading and the edges are low, then the edges have been at a high temperature for a sufficient length of time to allow grain growth. Photomicrographs have shown this to be true.

Dirty sheets, or those with a red surface or edges, have often been referred to as under-annealed, because in the stamping operations the breakage runs high. Erichsen tests on such stock usually run up to standard because the machine runs quite slowly and friction is low. In rapid stampings, this scale acts as an abrasive on the dies and in turn tears the metal. Therefore, the surface condition is very important. A polished or cold rolled sheet will stamp better than a simple pickled and annealed one. Because of the strains set up, cold rolled material is usually re-annealed, but even then the grain structure is poor.

(To be continued in November.)

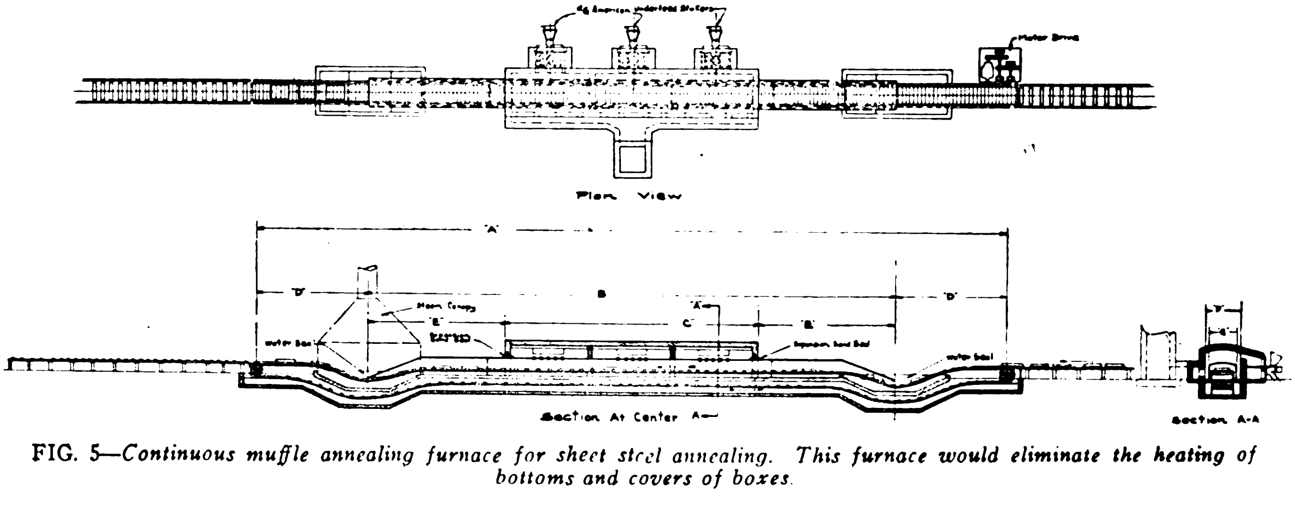
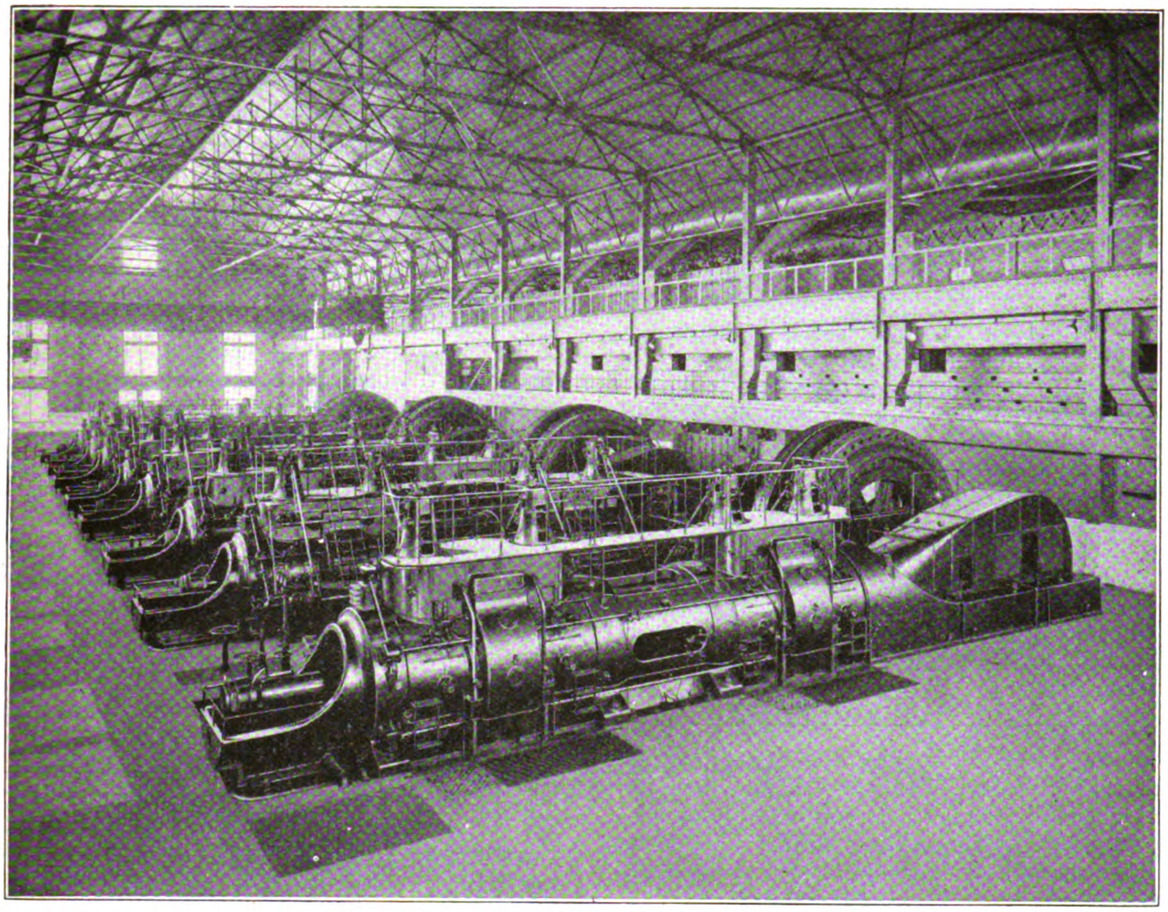


FIG. 5—*Continuous muffle annealing furnace for sheet steel annealing. This furnace would eliminate the heating of bottoms and covers of boxes.*

The POWER PLANT



Gas engine power house, South Works, Illinois Steel Company

THESE five engines are of the twin tandem type, having four double-acting cylinders, 48-in. diameter by 60-in. stroke, operating at 83-1/3 rpm.

The piston rods are 16 in. in diameter, hollow bored for water cooling; the crank pins are 21 in. x 19 in., and the main bearings 32-in. diameter by 54 in. long. Each engine unit weighs 1,000 tons.

The valve gear operates on a combination of the stratification system, varying the amount of gas per charge, and the throttling system,—combining the two methods so that the amount of the charge is reduced at light loads.

The washers and scrubbers which deliver the blast furnace gas thoroughly cleaned to these engines are models of completeness and efficiency.

Particular attention has been paid to water requirements, so essential to successful gas engine operation. While the sufficient supply available from Lake Michigan requires no special water treatment, all flows are metered and recorded.

The electrical output of this power house averages well over 13,000 kw. per hour—each engine in service delivering approximately 3,500 kw. on a consumption of 13,000 Btus. per kwh., with capacities up to 4,300 kw., which indicates a mechanical efficiency of nearly 25 per cent.

The United States Steel Corporation has installed and operating nearly 150,000 kw. capacity in gas engines, using blast furnace gas as fuel.

Power Plant Management*

Efficient Combustion Practice—Combustion Losses and How to Minimize Them

By ROBERT JUNE†

THE place to begin to save dollars in power plant operation is in the boiler furnace. Here we have opportunity to effect, not only greater proportionate savings, but larger actual savings in money, from an operating stand point, than anywhere else in the power plant. Efficient combustion practice is fundamental to the economical production of power.

Chemistry of Combustion.

Combustion is supported solely by oxygen and a combustible therefore is an element or compound which will combine with oxygen. Table I comprises the principal elements and compounds encountered in the combustion of coal, and shows the chemical reactions which take place. The ignition temperatures of the combustible constituents of the coals commonly used in boiler practice are also given in Table I.

This is the second in a new series of articles by Robert June, the well known authority on Power Plant Management. The articles are written from the point of view of the managing executive and deal with the dollars and cents end of power plant operation and maintenance. Succeeding articles deal with such live topics as Safe and Efficient Boiler Operation, Stoker Operation and Maintenance, What Management Should Know About Coal and Ash Handling Equipment, Steam Piping, Efficient Turbine Operation, Etc. The series is timely and should prove of value to our readers.

Air, a chemical mixture of oxygen, nitrogen, and slight traces of carbon dioxide, water vapor, argon, etc., is for the purpose of combustion considered to be proportioned as follows:

	By Volume Per Cent	By Weight Per Cent
O_2	20.91	23.14
N_2	79.09	76.85

The nitrogen in the air is a source of direct loss in combustion since it absorbs heat in its passage through the furnace. It is a further source of loss since space must be provided in the furnace, boiler passages, and chimney for its accommodation, which would not be required if pure oxygen could be supplied to the fuel.

The Btu. value of the various elements and compounds listed in Table I is given in Table II. This table shows vividly the difference in heat produced between burning one pound of carbon to carbon monoxide (CO), and burning the same carbon to CO_2. Nearly three times as much heat is produced in the latter case. High production of CO_2 then is essential to high combustion efficiency.

In studying Tables I and II it is well to remember that the heat value in the boiler furnace is dependent upon the final products of combustion, and that intermediate combinations which may have occurred, have no bearing upon the ultimate result.

The chemical composition of typical fuels with which we have to deal is found in Table III.

Air Required for Combustion.

The terms "perfect combustion" and "complete combustion" are frequently confused. Perfect combustion would result if all of the elements and compounds in the fuel were to be combined with oxygen which would be supplied in such proportions that all of the oxygen would be utilized. In distinction from this, complete combustion results from the oxidation of all of the elements and compounds, but it does not imply that all oxygen supplied is utilized. With "perfect combustion" there would be no boiler losses. With "complete combustion" boiler losses occur because of the presense of excess oxygen.

A real measure of the efficiency of combustion is found in the relations existing between the amount of air theoretically required for the burning of fuel and the amount of air actually supplied for such combustion. Table IV gives the theoretical air requirements of the various constituents of the coal. Table V shows the theoretical air requirements for various fuels and the resulting maximum per cent of CO_2 in the flue gas for complete combustion.

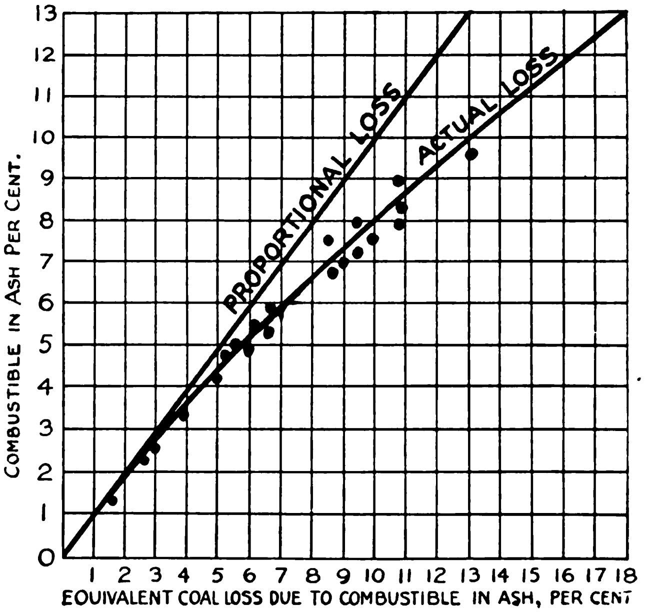


FIG. 1—*Curves showing losses due to combustible in the ash.*

Combustion Losses.

In order to utilize all the heat of combustion a boiler would have to be free from radiation and leadage losses, the coal completely oxidized, and the products of combustion discharged at atmospheric temperature. Commercially such conditions are unobtainable. A boiler which is operated constantly at 80 per cent over-all efficiency is extremely good practice. The various losses which occur in combustion, including the heat utilized by the boiler, constitute the "Heat Balance." The losses considered are:

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†Associate Member, A. S. M. E., Detroit, Mich.

1. Loss due to moisture in the fuel.
2. Loss due to hydrogen in the fuel.
3. Loss due to moisture in the air.
4. Loss of fuel through the grate.
5. Loss due to incomplete combustion.
6. Loss through the dry chimney gases.
7. Loss due to unburned fuel carried beyond combustion chamber.
8. Radiation and unaccounted for losses.

These will be considered separately.

Loss Due to Moisture in the Fuel.

Moisture in the fuel represents a very definite loss. It must be brought from atmospheric temperature to boiling point of 212 degrees, and again raised from 212 degrees to the temperature of the exit gases. At times firemen turn the hose on the coal pile. This is of value only to assist coking or reduce dust. The theoretical furnace temperature is decreased. Wet coal will only give a higher evaporation by preventing loss through the grate, or reducing the percentage of excess air in thin fires, as a result of packing the coal better.

Don't let your firemen run wild with the hose, and watch your step in purchasing coal, to see that the moisture content is specified and that deliveries conform to the contract, or else that proper adjustment is secured for excessive percentages of moisture.

Loss Due to Hydrogen in the Fuel.

The combustion of a pound of hydrogen results in the production of nine pounds of water vapor. This moisture must be heated and discharged at stack temperature. Further, since water is the direct product of combustion, the latent heat must be taken into consideration. Therefore, despite the fact that the combustion of a pound of hydrogen liberates 62,000 Btu., we find that the presence of hydrogen in anthracite coal causes an approximate loss of 2.5 per cent total heat value and with bituminous an average loss of 4.5 per cent of the total heat value of the fuel. This loss then can be minimized only where it is practical to substitute a low hydrogen fuel for a high hydrogen fuel, without additional cost or without affecting other factors.

Loss Due to Moisture in the Air.

This is usually a minor loss, but on hot humid days, or in regions where the air is constantly surcharged with water vapor it becomes appreciable. Since the moisture content of the air must be accepted as found, the only manner in which this loss may be kept in a minimum is by the reduction of the exit gas temperatures to the lowest practicable figure.

Loss of Fuel Through the Grates.

From 15 to 50 or 60 per cent of the total weight of refuse in the ash pit is combustible matter. The quantity of this unconsumed carbon in th eash in any given plant depends upon the size and quality of the coal, the type of grate, the rating at which the boiler is operated, and to some extent upon the skill of the fireman. In hand fired plants the total loss resulting from this waste of fuel has been found to range from 3 to 12 per cent or more of the total heat value of the fuel. Good stoker practice should show losses ranging from 1 per cent to a maximum of 5 per cent of the heat value of the fuel.

The only way to find out where your plant stands on this important point, is to have a series of analyses made of representative samples of ash. If you are not equipped to make such a test yourself you can send your samples to testing laboratories in any of the large cities, which will do this work for a nominal fee.

If you find that your losses are high, study the proportioning of the grate openings to the size of coal burned note further how your firemen handle the fire. You may find that your trouble is due to the use of coking coals, and that if it is practical to do so you will greatly reduce your losses by the substitution of free burning coals. With chain grate stokers an appreciable percentage of fine fuel may fall through the front end of the grate, and in such event it is possible to install a special hopper in the ash pit at this point to salvage the lost fuel.

Loss Due to Incomplete Combustion.

The difference between the burning of a pound of carbon to CO and burning it to CO_2 has been shown to be (see Table IV) 10,160 Btu. A very small per-

TABLE I — ELEMENTS AND COMPOUNDS ENCOUNTERED IN COMBUSTION

Substance		Atomic Weight	Molecular Weight	Reaction	Ignition Temperature Degrees F.	
Carbon	C*	12	..	(to CO) $2C + O_2 = 2CO$ (to CO_2) $2C + 2O_2 = 2CO_2$	(Fixed carbon bituminous) (Fixed carbon super-bituminous)	766 870
Carbon Monoxide	CO	..	28	$2C + O_2 = CO_2$	(Fixed carbon anthracite)	925
Carbon Dioxide	CO_2	..	44	....	....	1,210
Sulphur	S_2	32	64	(to SO_2) $S + O_2 = SO_2$ (to SO_3) $2S + 3O_2 = 2SO_3$	....	... 470
Sulphur Dioxide	SO_2	..	64	....	....	...
Hydrogen	H_2	1	2	$2H + O_2 = 2H_2O$	....	1,130
Hydrogen Sulphide	H_2S	..	34	$2H_2S + 3O_2 = 2H_2O + 2SO_2$	....	...
Oxygen	O_2	16	32	....	....	...
Nitrogen	N_2	14	28	....	....	...
Methane	CH_4	..	16	$CH_4 + 2O_2 = CO_2 + 2H_2O$	....	1,202
Acetylene	C_2H_2	..	26	$2C_2H + 5O = 4CO_2 + 2H_2O$	....	900
Ethylene	C_2H_4	..	28	$C_2H_4 + 3O_2 = 2CO + 2H_2O$	....	1,022
Ethane	C_2H_6	..	30	$2C_2H_6 + 7O_2 = 4CO_2 + 6H_3O$	....	1,000
Water Vapor	H_2O	..	18	....	....	...
Air	—	..	29	....	....	...

centage of CO in the flue gas is therefore fatal to high boiler efficiency. The extent of losses resulting from the presence of CO in the flue gas is shown graphically in Fig. 2.

Carbon monoxide being a colorless gas, its presence in the chimney gases cannot be detected by the absence of smoke. A clear stack does not indicate perfect combustion. If you find that you are running high percentages of CO look first to the method of handling the fire on the part of the firemen. Then check up your furnace design. Remember that if ample combustion space is not provided the volatile gases will be brought in contact with the boiler surface before combustion is complete, and the CO being thus reduced in temperature, may fail to unite with the oxygen to form CO_2.

Loss in the Dry Chimney Gases.

This is usually the greatest of all the losses. In even the best practice this loss is usually not far from 12 per cent with a general average of from 20 to 25 per cent. The size of the loss arises in the fact that stack temperatures less than 450 degrees are seldom found except in connection with economizers, and that temperatures of 600 to 700 degrees are by far more common. Fig. 3 shows the amount of heat carried away under varying conditions.

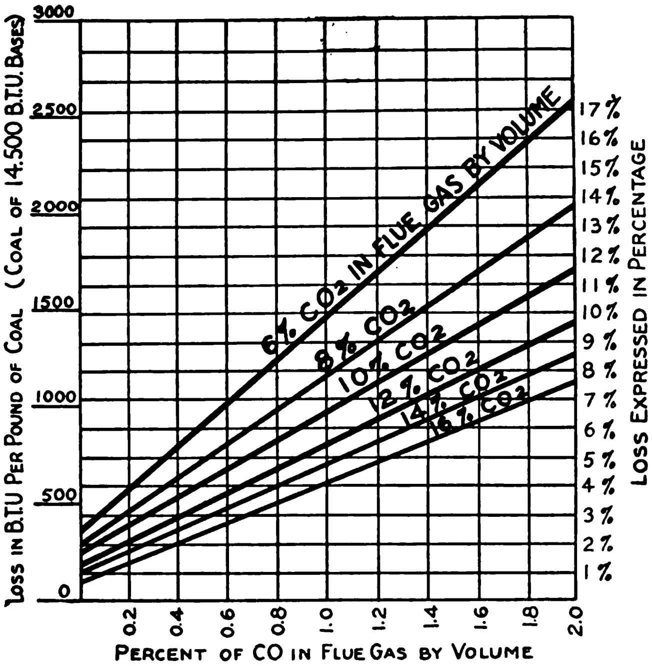

FIG. 2—*Curves showing losses due to CO.*

The quickest way to reduce this loss is by the installation and regular use of mechanical soot blowers. Put in soot blowers and you will find your stack temperatures reduced 60 to 100 degrees with a consequent direct saving in fuel of from 3 to 5 per cent.

Next cut down the amount of excess air admitted to the furnace to a minimum. Eliminate air in filtration by providing absolutely tight boiler settings. And finally keep the boilers free from scale so that they will readily absorb heat.

Loss Due to Unburned Fuel Carried Beyond Combustion Chamber.

When large quantities of unconsumed particles of carbon are deposited beyond the bridgewall, the fault is usually due to improper furnace design or to improper draft conditions. The fuel should be burned before it leaves the combustion chamber. If it is not the situation demands a special study of plant conditions.

Radiation and Unaccounted for Losses.

These losses which it is practically impossible to measure, include: 1. Radiation loss, which varies with the size of the furnace and boiler and condition of the setting. Careful tests on properly designed boiler furnaces show that the radiation loss in the very best practice does not exceed 2 per cent. 2. Losses due to unburned volatile hydro-carbons. 3. Loss due to the combination of carbon and moisture, with the consequent formation of hydrogen, ($C + H_2O = CO + H_2$), which may or may not be burned. This action may occur when wet coal is thrown on an incandescent fuel bed.

The test figures of 2 per cent radiation and unaccounted for losses can be approximated in the average boiler plant. Unfortunately these losses are usually sadly neglected. They are frequently found to amount to as much as 10 or 15 per cent due primarily to leaky boiler settings, as well as cinders blown out the stack under a high draft pressure. With improperly insulated boiler settings there is just one thing to do—build the walls thicker and insulate them properly.

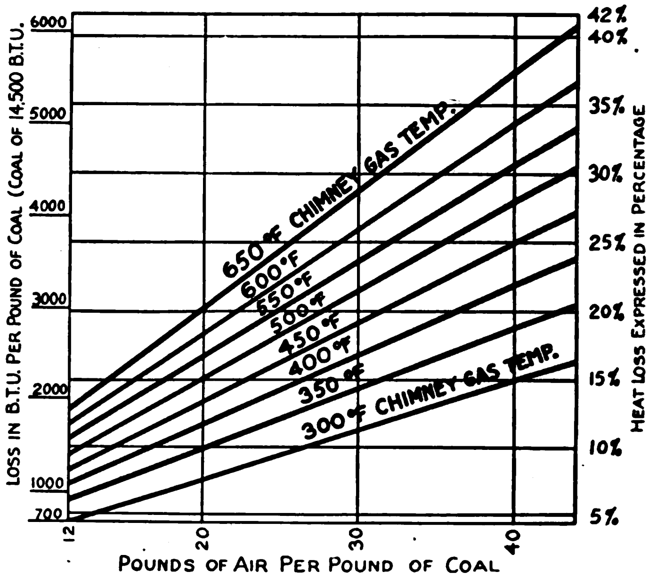

FIG. 3—*Curves showing losses varying with stack temperature.*

Smoke.

Smoke consists of the gaseous and solid products of combustion both visible and invisible, including substances carried in the atmosphere with the products of combustion.

The direct loss due to visible smoke is very small. Compilation of the results of a large number of tests show that this loss as represented by unconsumed carbon seldom exceeds 1 per cent. It is the invisible and practically colorless gases issuing from the stack which may represent combustion losses many times greater than that due to the actual carbon in the gases. A small amount of carbon will color an immense volume of gases.

As a matter of fact a smoky chimney may indi-

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TABLE II.
HEAT OF COMBUSTION BY CALORIMETRIC DETERMINATION

Combustible.	Btu. per Lb.	Btu. per Cu. Ft.
Hydrogen	62,000	348
Carbon (to CO)	4,380	...
Carbon (to CO_2)	14,540	...
Carbon Monoxide	4,380	342
Carbon in CO	10,160	...
Methane	23,850	1,073
Acetylene	21,460	1,590
Ethylene	21,450	1,675
Ethane	22,230	1,883
Sulphur (to SO_2)	4,050	...
Sulphur (to SO_3)	5,940	...

cate a much more efficient furnace than one which is smokeless, due to the fact that a furnace operating with a minimum air supply may cause dense clouds of smoke, and still give a higher evaporation than one made smokeless by a large percentage of excess air.

The loss due to unconsumed or partially consumed volatile hydro-carbons though not evident from the color of the gases issuing from the stack, may represent a very appreciable percentage of the total fuel fired. The way to determine this loss and to minimize it is by constant analysis of flue gas and by the application of remedies suggested by the results of such analysis.

TABLE III — COMPOSITION OF TYPICAL COALS — ULTIMATE ANALYSIS

	Carbon	Hydrogen	Nitrogen	Oxygen	Sulphur	Ash	Btu. by Calorimeter
Anthracite.							
Treverton, Pa.	90.66	1.73	...	0.78	...	6.83	13,980
Wilkes-Barre, Pa.	88.86	2.04	0.90	1.95	0.35	5.90	13,950
Drifton, Pa.	87.70	2.56	1.03	2.26	0.56	5.89	14,217*
Lehigh, Pa.	85.66	2.78	0.77	2.87	0.64	7.28	14,038*
Semi-Anthracite and Super-Bituminous.							
Bernice Basin, Pa.	85.46	3.72	1.12	3.45	0.91	5.34	14,552*
Coal Hill, Ark.	76.44	3.82	1.37	4.30	1.99	12.08	13,259
Pocahontas, W. Va.	76.51	4.27	1.00	6.59	0.51	11.12	13,509
Kanawha Series, W. Va.	81.95	4.30	1.29	3.68	0.97	7.81	14,686
New River, W. Va.	82.87	4.76	1.68	4.99	0.65	5.05	14,807
Clearfield, Pa.	80.32	4.88	1.46	4.69	1.00	7.65	14,432*
Bituminous.							
Freeport, W. Va.	77.82	4.89	1.48	6.52	0.90	8.39	14,069
Hocking Valley, Ohio	70.86	4.70	1.53	11.45	1.79	9.67	13,053
Pere Marquette, Mich.	79.44	5.29	1.56	9.84	1.11	2.76	14,160*
Brazil, Ind.	70.50	4.76	1.36	15.66	1.39	6.33	12,417
Eastern Field, Ky.	77.37	5.43	1.83	9.76	1.22	4.39	14,148
Horsecreek, Ala.	71.58	5.01	1.65	8.50	0.72	12.54	12,850
Fleming, Kansas	67.34	4.98	1.08	9.35	4.28	12.97	12,242
Laddadale, Iowa	59.82	4.81	0.94	13.40	5.03	16.00	11.027
Rich Hill, Mo.	57.00	4.97	0.94	12.48	5.25	19.36	10,586
Coffeen, Ill.	54.59	5.49	1.11	21.52	4.01	13.28	10,064

*Dulong's formula.

TABLE IV — PRODUCTS OF COMBUSTION — POUNDS PER POUND OF FUEL

	Theoretically Required Pounds		Products of Combustion, Pounds				
	O_2	Air	CO_2	H_2O	N_2	CO	SO_2
Carbon (to CO_2)	2.667	11.52	3.667	...	8.85	....	...
Carbon (to CO)	1.333	5.76	...	...	4.43	2.333	...
Carbon Monoxide	0.572	2.46	1.57	...	1.89	....	...
Sulphur	1.000	4.32	...	...	3.32	....	2.00
Hydrogen	8.000	34.56	...	9.00	26.56	....	...
Methane	4.000	17.28	2.75	2.25	13.28	....	...
Acetylene	3.077	13.29	3.39	0.69	10.21	....	...
Ethylene	3.429	14.81	3.14	1.29	11.38	....	...
Ethane	3.733	16.13	2.93	1.80	12.40	....	...
Hydrogen Sulphide	1.412	6.10	...	0.53	4.69	....	1.88

TABLE V — THEORETICAL AIR REQUIREMENTS FOR VARIOUS FUELS AND THE RESULTING MAXIMUM PER CENT CO_2 IN THE FLUE GAS FOR COMPLETE COMBUSTION

Fuel, Moisture and Ash Free	Ultimate Analysis					Air, Pounds		
	C	H	N	O	S	Per pound of Fuel	Per 10,000 Btu.	CO per cent by Volume
Anthracite	94.39	1.77	0.71	2.13	1.00	11.39	7.4	20.06
Semi-anthracite	89.64	3.97	0.63	3.23	2.53	11.59	7.5	20.00
Super-bituminous	86.39	4.84	1.46	5.50	1.81	11.41	7.6	18.65
Bituminous	79.71	5.52	1.52	9.87	3.38	10.70	7.4	18.46
Sub-bituminous	78.06	5.70	1.35	13.10	1.79	10.24	7.3	18.56
Lignite	70.64	4.61	1.22	22.67	0.86	8.75	7.3	19.68

TABLE VI — PER CENT OF CALORIFIC VALUE OF COAL AS FIRED

Heat Absorbed and Losses Itemized	Highest Attainable Efficiency	Excellent Practice	Good Practice	Average Practice	Poor Practice
Heat absorbed by boiler	89.86	80.0	75.0	65.0	60.0
Loss due to free moisture in coal	0.50	0.5	0.6	0.6	0.7
Loss due to hydrogen in coal evaporation of H_2O	4.20	4.20	4.30	4.3	4.4
Loss due to heat in dry flue gases	5.33	10.0	13.0	17.5	20.0
Loss due to carbon monoxide	0.00	0.2	0.3	0.5	1.0
Loss due to combustible in ash and refuse	0.00	1.5	2.4	4.5	5.5
Loss due to heating moisture in air	0.11	0.2	0.2	0.3	0.4
Loss due to unconsumed hydrogen, hydrocarbon, radiation and unaccounted for	0.00	3.4	4.2	7.3	8.0
Calorific value of coal	100%	100%	100%	100%	100%

Stand-by Losses.

Stand-by losses include: (a) Heat lost in shutting down boilers; (b) coal required to start up cold boilers; (c) fuel required in banking fires; (d) heat lost in "blowing off" and cleaning boilers. Depending upon the size and character of the boiler equipment and the conditions of operation stand-by losses will range on the average from 5 to 15 per cent or more of the total heat generated over the period of a year. This means that if your boiler normally operates at an efficiency of 70 per cent for example, that its actual efficiency over a period of a year is probably not to exceed 60 per cent. Bearing this fact in mind, efficient power plant management demands that the closest watch be kept on the detail of taking off or putting boilers on the line. It is better to work three boilers continuously at a high rating if this can be done, than to work four intermittently.

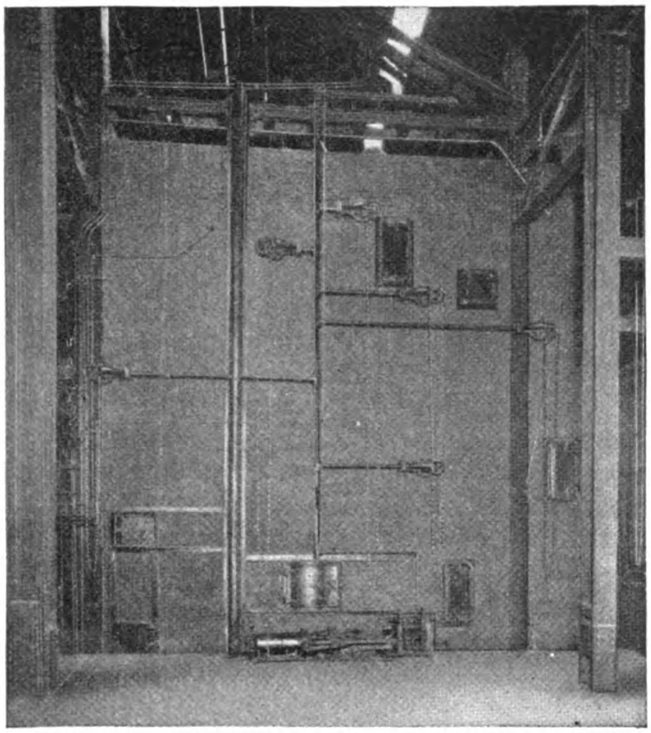

FIG. 4—*A boiler equipt with automatic combustion controls.*
[illegible]

Heat Balance.

The heat balance consists of a chart on which a summary is made of the various losses together with the amount of heat absorbed by the boiler. It is a bookkeeper's device, very valuable to the power plant operator, for it shows him at a glance where his losses are and thus in itself suggests means for minimizing them.

A representative heat balance is shown in Table VI. To the operating man this table is of value for purposes of relative comparison only. The actual heat balance for any given plant must be worked out on the ground, with reference to the grade of fuel, type of furnace and grate, rating at which the boiler is driven, and similar factors.

Improving the efficiency of a boiler plant is a man size job. It requires enthusiasm, patience and persistence, but given these the reward is certain.

Study Coal Mining Problems

The six college graduates who have been appointed to the annual Research Fellowships at Carnegie Institute of Technology in Pittsburgh have already begun their studies of a wide variety of coal mining problems. A significant feature of the research program for the year 1923-24 lies in the fact that two of the fellowships were newly established in order to carry on studies specifically requested by two private firms in the coal industry, both companies having agreed to finance the research work.

The assignment of problems has been made as follows:

"The relation of acidity and oxygen to corrosion of metals and alloys in acid mine waters," Ralph E. Hall, physical chemist, U. S. Bureau of Mines, and Research Fellow W. W. Teague, B.S., University of Alabama.

"A study of efficiency in blasting coal," J. E. Tiffany, explosives testing engineer, U. S. Bureau of Mines, and Research Fellow C. W. Nelson, B.S., Carnegie Institute of Technology. (Requested and financed by the Hillman Coal & Coke Company.)

"A study of the practicability of gas masks and protection afforded by them in mine atmospheres," G. S. McCaa, mine safety engineer, and S. H. Katz, associate physical chemist, U. S. Bureau of Mines, and Research Fellow A. L. Barth, B.S., Pennsylvania State College. (Requested and financed by the Mine Safety Appliances Company.)

"Correlation of coal beds in the Allegheny formation of Western Pennsylvania and Eastern Ohio," Reinhardt Thiessen, research chemist, U. S. Bureau of Mines, and Research Fellow F. D. Wilson, M.A., University of Oregon.

"Effect of wheel diameter and other variables in friction losses in mine car running gear," Mayo D. Hersey, physicist, U. S. Bureau of Mines, and Research Fellow Howard E. Wetzel, B.S., Pennsylvania State College.

"The time rate of combustion of coal dust particles of definite sizes," C. M. Bouton, associate research chemist, U. S. Bureau of Mines, and Research Fellow J. M. Pratt, M.A., Swarthmore College.

Hydraulic Turbines of Large Capacity

References to Refinements in Design, Increased Efficiency and Advances in the General Art of Large Turbines

By H. G. ACRES*

On New Year's Day of 1905, in the plant of the Canadian Niagara Power Company, it fell to the author's lot to bring up to speed, for the official inspection of the Provincial Park Commissioners at Niagara Falls, Ontario, two 10,000-hp. turbines, the largest units ever built up to that time. Almost exactly 17 years later it was again his privilege to turn over the first of the five 55,000-hp. turbines now installed in the Queenston plant of the Hydro-Electric Power Commission at Niagara, the largest capacity units at present in operation. It was this more or less fortuitous combination of circumstances which suggested a subject for discussion.

Not in any sense as a precise definition, but for the purpose of placing a reasonable limit on the scope of discussion, a hydraulic turbine of large capacity may be defined as one having a capacity of not less than 25,000 hp. and a revolving weight, with the generator rotor, of not less than 200 tons, exclusive of hydraulic thrust.

The above limitation on capacity and revolving weight will serve the double purpose of eliminating from the discussion any consideration of low-head installations and at the same time giving prominence to certain problems which become increasingly serious as the operating head ranges upward from 70 to 80 ft. As units of the class which has just been defined above are rarely installed under heads as low as this specified minimum, the discussion is therefore more or less limited to medium and high head plants.

Where a high operating head is involved, there is always present the problem of controlling high static pressure in the interest of safety; and in most cases there is also the problem of controlling and utilizing the flow characteristics of long pipe lines to insure not only safe but practicable operation. Finally, where a copious water supply is associated with a high head, there enter the problems of safely and efficiently controlling a heavily energized water column, and handling the immense revolving weight of the modern super-turbine.

Static-Pressure Control.

Control of static pressure involved in super-turbine water supply is a vital factor in relation to a maximum degree of safety and convenience in operation, and in continuity of plant output. Obviously the mechanism to exercise this function is a valve, and such a valve, for super-turbine service, must have the following general specifications:

(a) It must be built in any size necessary to accommodate any conduit, however large.

(b) It must be designed to operate under any static head, however high.

(c) Its operation must at all times be safe, sure, and positive, in opening under full static pressure, and in closing under the most serious plant emergencies, such as the breakage of a wheel case or a runaway resulting from failure of governor control.

(d) It must open and close rapidly, and should have an automatic closing feature to meet the above-mentioned emergency conditions.

Obviously such a specification could not be met by any valve of the ordinary type, nor was it met until the advent of the Johnson automatic plunger valve. This is now an indispensable adjunct to super-turbine installation, and constitutes one of the advances in the general art which contributed to the possibility of present-day super-turbine development.

Flow Control.

In the majority of cases the development of a high head involves the use of some type of closed pressure conduit of considerable length. In the case of an automatically governed plant where the ratio of head length of conduit is more than about 1:10, certain phenomena become manifest which constitute a serious menace to safe and practicable operation. The continuous rejection and pulling on of a load increments causes recurrent surges throughout the length of the conduit, which, if not damped out or relieved, will sometimes multiply and become superimposed to such an extent as to cause pressure enormously in excess of the static head. This condition, in conjunction with the conversion of pressure into velocity head for acceleration purposes, when a large increment of load is pulled on will impose a duty on the governors which they are not intended to perform, and where long closed conduits are used with turbines gated beyond the point of maximum efficiency, as they nearly always are, a condition may obtain which is entirely beyond the regulating function of the governor.

The power-discharge curve for the ordinary turbine will show a maximum production per second-foot at the point of best efficiency and the first derivation of this curve will show a rapidly decreasing rate of production per second-foot from that point to full gate. Consequently, every horsepower pulled on in excess of best-efficiency capacity will require a rapidly increasing amount of water to produce it. If therefore, the turbine is operating at or beyond the point of maximum efficiency, when the system demands a large increment of load there will be a falling off in production per unit of water supplied, and coincident therewith a loss of effective head, due to the absorption of such velocity head as is necessary to accelerate the water column. It is therefore evident that during the period when the water column is accelerating, a condition may obtain where the power output is actually falling off while the water input is increasing, the result being that the governor may open the gates full stroke in response to the falling speed, at which point its controlling function will cease, until either the system wr^2 holds the unit, with dropping frequency, for the space necessary for the governor to gradually resume control on rising speed, or until the generator drops its load and the turbine jumps to runaway speed at full gate, with possible disastrous consequences.

In so far as the control of surge pressures is con-

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*Chief Hydraulic Engineer, Hydro-Electric Power Commission of Ontario. Paper presented at the spring meeting, Montreal, Canada, of the American Society of Mechanical Engineers. Slightly abridged.

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cerned, it is evident that if no practical limitations are placed upon it in the matter of diameter and height, the ordinary standpipe would be an ideal corrective agency. It is clear, however, that in the case of a super-turbine installation unrestricted scope in design is wholly impracticable from the standpoint of both cost and space limitation. On the other hand, a simple standpipe, feasibly designed and located, may at times actually make more acute the conditions it is designed to correct or alleviate. This is due to the fact that the simple standpipe can only passively absorb surge pressure, with its recurrent phases, and for this reason often acts as an agency for superimposing, one upon the other, pressure waves generated by successive changes in load.

Another obvious expedient under this head is to limit the range of velocity change in the conduit by means of a synchronous bypass, actuated by the governor mechanism. This contrivance can be adjusted to prevent the occurrence of disruptive pressures in the conduit, and also to supplement the influence of the system **wr_2** in holding the unit within the regulating range of the governor when the unit is pulling on or rejecting load. In this connection it is to be noted that the condition under discussion has not necessarily to do with the maximum conduit velocity at any one time, but with the **range of change** in conduit velocity over a short period of time, and with the absorption and building up of head energy induced by these changes, within their low and high limits.

The synchronous bypass therefore has a useful function, but in the case of a high-head super-turbine installation its usefulness would be largely discounted by its cumbersome dimensions, its waste of water, and an added mechanical complexity which should be avoided whenever possible as a matter of principle.

The discussion under this head has now reached a stage where it is possible to define the specifications of an ideal surge-control agency.

(a) It should have the effectiveness of a simple standpipe of very large dimensions, without its cost and space requirements.

(b) It should be capable on the one hand of preventing or counteracting the effect of any undue absorption of head energy when load is pulled on, and, on the other hand, of preventing or counteracting the effect of any serious recurrent surge pressure arising from load rejections, whether isolated or successive.

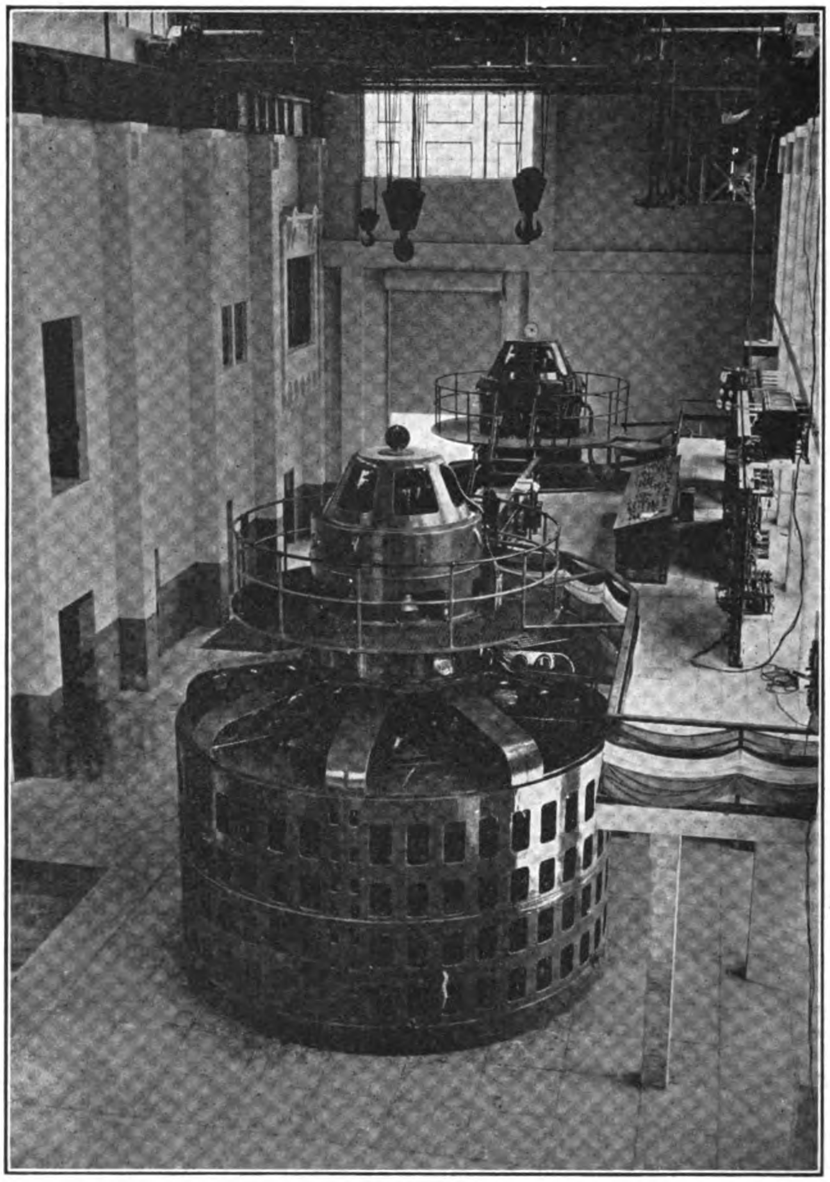
(c) The water surface should be sufficiently active to prevent freezing in ordinary low temperatures, and the dimensions should be such as to allow feasible and effective frost protection against extraordinarily low temperatures.

(d) It should operate without wasting water.

(e) It should be mechanically simple, with a minimum of moving parts and adjustments.

(f) It should be entirely dissociated from the governor mechanism, leaving the governor free to perform its own peculiar and highly important functions, which is to control the speed of the generator, and not the vagaries of the water column.

This specification has been met with a large degree of effectiveness by one of the most wholly original and at the same time most useful contrivances ever developed in the field of hydraulic engineering, namely, the Johnson differential surge tank. Ample published data are available concerning its structural details and operating principle, and it is only necessary to state here that this contrivance constitutes another of the essential advances in the hydraulic art which have made possible the development and safe operation of the super-turbine.



The largest 60-cycle generators yet built; output, 46,000 hp. each.

Revolving Weights.

The handling of the revolving weight of a modern super-turbine is governed largely by consideration of efficiency, a matter which will be discussed later, only the mechanical aspect of the problem being considered at this time.

In the early days of hydraulic-turbine development the step bearing, a form of combined thrust and guide bearing located under the runner, was used almost exclusively for the support of revolving element. The subsequent gradual increase in the efficiency, speed, and capacity of turbine runners then began to introduce problems of pressure intensity, depreciation, and accessibility, which the designers of that day solve, not by improving the step-bearing principle, but by abandoning it and inaugurating, as a result, the era of the horizontal-shaft turbine. This led to advanced development in bearings of the pillow-block type, together with the introduction of marine-type thrusts bearings to take up unbalanced runner thrust, a double requirement which gave rise to serious problems when the development of electrical generation and transmission called for continuously increasing turbine capacity and speed.

The original turbines installed in 1896 by the Niagara Falls Power Company represent the first reversion to the primitive basic principle. They were the super-turbines of that period, and were of the vertical-shaft type. The revolving weight of these units was partially suspended from and partially superimposed on a step bearing located above the runner and immediately below the generator, thus removing one of the main disadvantages of this type of bearing, that of inaccessibility. A further important innovation was the application of external pressure to a film of oil which was forced in between the moving and stationary elements of the bearing.

The oil-pressure thrust bearing had a vogue of many years' duration, and some bearings of this type are still in operation. Their disabilities are: expensive investment and maintenance cost, mechanical complexity, and high temperature, resulting in low oil viscosity and high energy losses. Also, even a momentary failure of the pressure-oil supply usually results in the loss of the bearing.

Finally there came the ultimate conception, based on the simple and true embodiment of a basic principle first established by the experiments of Tower in 1883 and afterward mathematically demonstrated by Reynolds. It remained for Kingsbury to exemplify this principle in a mechanism which is one of the most outstanding examples extant of the simple and efficient application of a natural law.

The Kingsbury-type thrust bearing has the following characteristics which distinguish it from its oil-pressure prototype and make it an eminently suitable mechanism for supporting, in motion, the revolving weight of the modern super-turbine:

It can be adapted to safely support the revolving weight of the heaviest turbine, within feasible dimensional limits.

The source of oil supply is static, and integral with the bearing itself.

The oil supply is "unlimited" in the sense necessary to conform with the laws of motion of viscous fluids, as enunciated by Reynolds.

The formation of the "pressure wedge" is not induced by any external agency but by the motion of the bearing itself, and by providing for a very slight lack of parallelism between the stationary and moving elements.

The wedge pressure is a direct function of the speed of the moving element, and the thickness of the oil film is a direct function of the degree of viscosity of the fluid, and consequently of fluid temperature, which can be regulated within any desired limits by the simple expedient of water-cooling coils.

Apart altogether from their very material contribution to operating efficiency, the mechanism above discussed introduce a factor of safety and dependability, either singly or in combination, without which the present day status of super-turbine development would have been unattainable.

Refinements in Design.

The items above classified as essential advances have been radical departures from contemporary practice, and have actually opened up the possibilities of super-turbine development, whereas the turbine governor has been enlarged and improved more or less synchronously with the enlargement and improvement of the hydraulic turbine, and to meet the constantly increasing importance of the duty it has been called upon to perform.

Governors. As the primary requirements of governor operations are precision and reliability, the natural trend of design has been in the direction of simplicity in principle, the reduction of lost motion by the use of minimum of moving parts, and precise shop work. An interesting development along this line is the White shaft governor, where the centrifugal element is attached direct to the main turbine shaft, thus obviating the complication of a belt or gear drive for the flyballs.

The double compensation principle, with the restoring mechanism and load-limiting attachment, appears to meet all requirements of super-turbine governor control adequately and safely, and speed regulation is assured within safe operating limits for all gate movements up to the full stroke of the servomotors.

Remote switchboard control has also been developed to such a stage that there is considerable latitude as to the location of the actuator, which in some cases is now placed directly over the servomotor cylinders, in others on the machine-room floor, and sometimes on the switchboard gallery.

A useful adaptation of the Johnson valve principle has been devised by Taylor for interchanging governor and hand control. Two sets of plunger valves are used, one set on the governor and one on the hand control, and the throwing over of one hand lever will simultaneously close all the governor valves and open all the hand-control valves, or vice versa. This operation can be carried out in such a short interval of time that there is little or no chance of losing control of the turbine, and no chance whatsoever of interfering with the proper sequence of operation.

One of the latest innovations in governor design is a a motor-driven centrifugal element, the motor being located on the flyball spindle and synchronously actuated by the main generator. This device serves the same purpose as the shaft governor in that it eliminates the belt or gear drive.

Draft Tubes. The activity which has manifested itself during the last four or five years in draft-tube investigation is directly traceable to the vogue of the super-turbine. There are two main reasons for this: first, the large concentration of power in a super-turbine permits an appreciable increment of useful power to be reclaimed as the result of a gain of only a fraction of one per cent in overall efficiency; and second, the vibration resulting from vortex action and unsteady vacuum becomes magnified in the super-turbine to such an extent as often to cause serious inconvenience in operation. The pioneer development under this head was the White hydraucone, which marked a distinct advance in this branch of the art.

Briefly, the twofold object of recent draft-tube experimental research has been to regain as much as possible of the whirl component of the velocity head in the runner discharge, and to devise means of so training the combined axial and whirling flow, through appropriately designed water passages, as to minimize conditions giving rise to vibratory effects. All experiments carried on along this line by the principal turbine builders have definitely proved the inadequacy of all forms of the elbow-type tube, which have given satisfactory results when tested under operating conditions. Of these types the Moody spreading tube seems to conform most nearly to one's conception of the conditions to be met. This is particularly the case in respect of a cone in the center of the Moody tube which extends from the invert to the lower extremity of the runner hub. Inasmuch as this cone solidly fills the region of maximum turbulence, it seems entirely reasonable to assume, even without experimental confirmation, that it will be effective in preventing cavitation and the formation of vortices, with their resultant vibratory effects. Serving this purpose it also naturally follows that it must affect a useful conversion of the hitherto wasted whirl energy of the central zone, realizing thereby a gain in efficiency as well as a betterment in operating conditions.

Leakage Prevention. In a small high-head plant with which the author had something to do the turbine showed 85 per cent efficiency on acceptance test. A year later the efficiency had dropped to 67 per cent by reason of excessive leakage through the runner clearance spaces. The head in this case was 550 ft. and the circumference of the clearance spaces was about 14 ft. In the case of the 55,000-hp. turbines at Queenston the head is about 250 ft. less, but the circumference of the runner clearances is about 65 ft. It is evident, therefore, that in the case of a runner of this size, under such a head, the leakage factor is a serious matter. As a matter of fact, two of the most recent refinements in turbine design have been devised for the express purpose of meeting this condition: namely, the so-called "labyrinth seal" for preventing leakage through the runner clearance space, and the Overn disk for preventing leakage through the gate clearances.

Instead of the ordinary simple seal consisting of a straight annular passage past the crown of the runner into the space under the head cover, and a similar passage past the runner band into the draft tube, the labyrinth seal, Fig. 1, consists of a series of alternately expanded and contracted passages which destroy the velocity head and reduce the head on the final free jet to one-third of its initial value.

The Overn disk, Fig. 2, functions by introducing into the clearance space between the end of the gate vanes and the distributor plates an obstruction to the leakage flow considerably greater than the diameter of the gate shanks, thus effectively reducing the leakage at these points.

Taylor Sectional Scroll Case. Where the head is sufficiently high to require the use of a cast-steel scroll case, a serious problem is introduced which has to do with the cantilever strain on the radial joints between the speed ring and the scroll case. With the ordinary design, efficient bolt distribution is not practicable, and in the shop pressure test, where the scroll is not supported by a surrounding mass of concrete, the bolts are sometimes stressed beyond the elastic limit, with resultant serious leakage. This disability can be largely overcome by casting the speed-ring stay vanes integral with the scroll sections, but the pouring and annealing of such a casting is a most difficult piece of work and the results are not always certain. The Taylor sectional scroll case is just as effective and largely removes any uncertainty as to the quality of the casting. Taylor's method, see Fig. 3, is to cast the speed-ring stay vanes integral with a small radial section only of the scroll, and connect later by means of a joint to the main section of the scroll. This joint is so located as to permit of a heavy flange and efficient bolt spacing, and the castings are of such shape and dimensions that there is every assurance as to their quality after leaving the annealing furnace.

The showing made by the sectional scroll case under shop pressure test indicated that no undue risk would be involved in setting the scroll in the open, with only so much concrete as might be necessary to secure a stable anchorage.

With regard to the pitting and erosion of runners, it may be said that super-turbine development has now reached a stage where this condition is no longer primarily a problem of design but of economics. In other words, if the customer so specifies, the manufacturer can select a specific speed and supply, at a price, a turbine in which the runner will have as long a period of useful life as the other major elements of the installation.

Such a specification on the part of the customer would, of course, involve additional capital expenditure for the generator as well as for the turbine, but as against this aspect of the situation it must be realized that the modern super-turbine frequently has a capacity which enables it to earn upward of $2,500 every 24 hours. Consequently the lost revenue charge against runner replacement in a fully loaded unit may easily run as high as $25,000. If this were necessary every two years, it would be equivalent, on a 6 per cent basis, to a capital charge of $200,000. Such being the case, it is evident that the choice of a proper economic specific speed is a matter deserving the most careful and mature consideration, being a factor of at least equal importance with proper gateage and elevation relative to tailwater.

Efficiency.

The overall maximum efficiency of the Queenston units is well beyond 90 per cent, and within their maximum efficiency range they deliver about 32 e.hp. to the switchboard for every second-foot of water supplied under 305 ft. of net head. Under such conditions a variation of 1 per cent, one way or the other, on one of these 55,000-hp. units would mean either the lack, or the availability, of sufficient power to meet the requirements of an average community of 2,000 population. This statement should serve to emphasize the significance of high efficiency as related to super-turbine practice.

The primary factor making for high efficiency is a minimum of obstruction to the direct flow of water from forebay to tailrace. This consideration involves water passages, of ample section, with changes in direction of flow eliminated wherever possible, and where unavoidable, careful proportioning and transitioning.

(To be continued)

A PAGE OUT OF HISTORY

On page 518 we reproduce an historical page from Harper's Weekly published in 1876.

These wood cuts emphasize clearly the marvelous changes which modern science has wrought in the steel industry. At that time a Bessemer converter was a thing of wonderment, as it truly deserved to be—today Bessemer converters have given place to further demands for improved quality and uniformity.

As we view the future of electrical applications, we wonder what greater miracles will be unfolded.

CURRENT TECHNICAL DIGEST

The Story of Oil

The Scientific American for October has a very timely "Story of Oil."

Early in the last century petroleum was a nuisance. The oil seeped into salt wells and spoiled what was an altogether more valuable commodity.

Later it was demonstrated that the oil had lubricating properties far superior to the animal oils and greases then in general use. It was also discovered that by filtering the crude petroleum through charcoal, or refining it in crude stills, much of the offensive odor could be removed and the illuminating power enhanced.

Thus, by slow steps, the use of petroleum increased until the old method of recovering it from the surface of pools and springs failed to yield sufficient oil to supply the demand. And, so, in August, 1859, Colonel Edwin L. Drake drilled in the first commercial oil well in this country near Titusville, Pa. This little well—it was only 69 feet deep and its total yield that first year was less than 2,000 barrels—was the real beginning in the United States of what is today one of the world's greatest industries, without which modern social and industrial life would be impossible.

Following Drake's effort, a wave of development swept over the Pennsylvania oil fields, spreading to Ohio, West Virginia and Kentucky, and, later, to the great mid-continent and California fields, which today are the most important oil-producing territories in the world.

The change has occurred since 1906, when the main purpose of the petroleum industry was to supply the world with an illuminant—kerosene—of which about 33,000,000 barrels were produced in that year.

Since 1906 the internal combustion engine has come into universal use. Kerosene is no longer the principal commercial product of crude petroleum. Its place has been taken by gasoline and today the industry's reason for being is to supply the world with constantly increasing quantities of motor fuel. It is interesting to note that last year the production of kerosene was about 55,000,000 barrels, or an increase in 16 years of slightly more than 63 per cent, while the production of gasoline was about 143,000,000 barrels, compared with only 8,000,000 in 1906, or an increase of 1750 per cent.

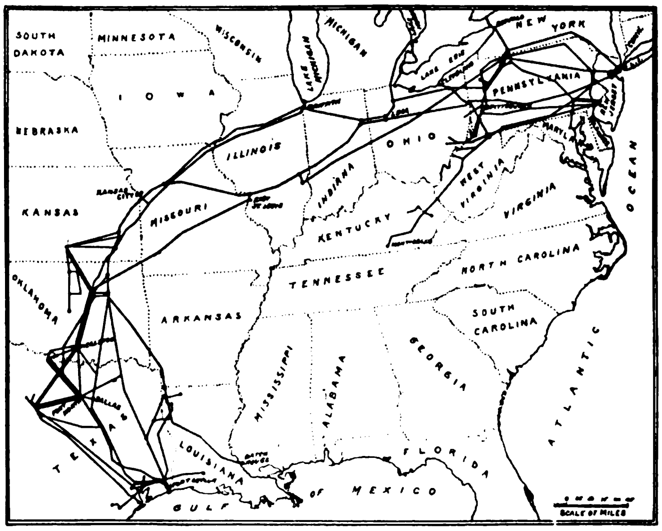
The United States produces about 62 per cent of the world's supply of crude petroleum. There are at present more than 280,000 producing wells in this country and the 1922 output was 550,000,000 barrels of 42 gallons each.

Oil wells vary in depth, according to the territory in which they are drilled, but the average depth of all wells drilled in 1922 is estimated at 2827 feet.

The average yield of all wells in the United States is in the neighborhood of five barrels a day.

Occasionally it happens that a well does not yield freely or shows signs of exhaustion, and "shooting" may be advisable to loosen the oil sand and stimulate the flow. This is done by lowering a torpedo loaded with nitroglycerine to the proper depth and exploding it. The quantity of nitroglycerine used varies with conditions, but up to 160 quarts has been fired in a single charge. Shooting is not always successful and wells have been ruined by too great disturbance of the oil-bearing sand.

As the crude oil comes from the well it is run into field storage tanks. These are comparatively small steel or wooden containers and are not intended to retain the oil for any length of time. It frequently happens, especially where wells come in with a heavy initial flow, that earthen storage is used, the earth being banked up to hold the oil in a large pool. This method is wasteful owing to evaporation, losses as high as 40 per cent having occurred.



Map showing the 60,000 miles of pipe line, mostly 8-inch, by which the crude oil is distributed throughout the United States.

It is at this point that the production and transportation branches of the industry overlap. The oil is taken from field storage through a system of so-called gathering lines which are of 2- to 6-inch steel pipe through which the oil is pumped to the "tank farm." This is a collection of huge steel tanks where the oil is gathered before being distributed by trunk pipeline to the refining centers.

There are more than 60,000 miles of trunk pipeline, usually of 8-inch steel pipe, operating from the producing fields across country to terminals located on the Atlantic, Gulf and Pacific coasts, where the oil is refined or shipped as crude in tank steamers or cars. The trunk pipelines are common carriers and are under the control of the Interstate Commerce Commission. At intervale on the lines are pumping stations to force the oil along. In the Eastern and mid-Western regions, these stations are about 35 miles apart, but in California, where the oil is much heavier, pumping stations are located every 12 miles or so and even then it is sometimes necessary to heat the oil.

Employed in the transportation of oil, both crude and refined, are more than a thousand tank steamers, or tankers, as they are called. Of these nearly 400 are under American registry. The average capacity of the American tankers is 67,000 barrels.

The refining of crude requires complicated apparatus, but the operation may be briefly described as progressive distillation at successively higher temperatures. Gasoline being the most volatile product, is naturally driven off at the initial heating. The temperature is then increased and kerosene results. Thereafter come in order gas and fuel oils, lubricating oil, paraffine wax, coke and asphalt, depending upon whether the crude has a paraffine or an asphalt base, and lastly a variety of minor products the character of which also depends upon the crude.

The average yield of refined products from a 42-gallon barrel of mid-Continent crude is as follows: Gasoline, 25.6 per cent; kerosene, 9.7 per cent; gas and fuel oils, 47.9 per cent lubricating oil, 4.3 per cent; wax, coke and asphalt, 2.4 per cent; miscellaneous products, 6 per cent; loss in refining, 4.1 per cent.

A method of increasing the yield of gasoline by what is known as the "cracking" process has been perfected and is in use in 127 of the larger refineries. This involves the redistilling under pressure of gas and fuel oils so that the molecules are disintegrated or "cracked." By this process the average gasoline yield of mid-Continent crude has been increased from 8 to 15 per cent. The cracking system is costly to install, however, and is practicable only for refineries having a large and constant run.

Gasoline, kerosene and lubricants are shipped to market or pier in barrels, drums, wood-encased cans—the case of oil of commerce—or tank cars. Domestic bulk shipments are made exclusively in tank cars. These cars are familiar sights to the traveler. There are about 133,000 of them in the petroleum service in the United States, with an average capacity of 8,000 gallons. All but 11,000 are privately owned, that is by refining and oil transportation companies.

The consumption of gasoline in the United States alone last year was nearly 5,350,000,000 gallons, in addition to 600,000,000 gallons exported.

It is estimated that each registered automobile, including trucks, taxicabs, buses and pleasure vehicles, consumes about 425 gallons of gasoline a year. This estimate makes no allowance for airplanes, motor boats, tractors or other internal combustion engines. Of course, the gross consumption increases from year to year. The 1922 consumption of 107,000,000 barrels was 26 per cent greater than that of 1920 and 18 per cent more than that of 1921. The consumption during April of this year was at the rate of 140,000,000 barrels a year, or 7,000,000,000 gallons, plus exports of 14,000,000 barrels, or 700,000,000 gallons, and April is not ordinarily a month of peak consumption.

Export Field for Iron and Steel Products

"Commerce Reports" for September 24 has the following:

In press and journal reports from principal producing and consuming countries of iron and steel it is generally acknowledged that there is a world shortage of steel products. It is conceded that the domestic demand, except in the United States and Germany and to a certain extent in the United Kingdom, France, and Belgium, has fallen off. New developments of resources which would require the use of vast quantities of steel have been held up. Replacements for the repairs to existing equipment have been kept at a minimum.

The United States is the greatest producing nation of iron and steel. As to capacity, the United Kingdom, Germany, and France follow in order of their importance. It is not possible to say at this time which of the two, Germany or France, has the greater capacity, but if that of the Ruhr is added to the French it is safe to say they are about equal. Belgium and Luxemburg fall into a secondary class as to volume of possible production when compared with the main group.

Accurate data for Germany are not available. From the following production figures, reported for the first half of 1923, we can judge what three of the primary units have done:

IRON AND STEEL PRODUCTION FOR FIRST TWO QUARTERS OF 1923

	Pig Iron		Steel Ingots	
Countries	First quarter	Second quarter	First quarter	Second quarter
United States ..	9,747,659	11,093,875	11,324,141	11,889,102
United Kingdom	1,744,900	2,059,300	2,243,700	2,338,100
France	1,090,440	1,150,500	997,370	1,152,550

July figures indicate that this rate of output is being maintained. The production of pig iron and steel ingots for July is reported as follows: United States, 3,678,334 gross tons of pig iron and 3,515,966 of steel ingots United Kingdom, 655,100 of pig iron and 624,300 of steel ingots; and France, 430,000 of pig iron and 393,200 of steel ingots.

Belgium production for the first quarter of 1923 amounted to approximately 475,000 gross tons of pig iron and 485,000 tons of steel, while the corresponding figures for Luxemburg were 320,000 and 172,000 tons, respectively. These two units in the secondary group are mentioned in this discussion, due to the fact that although their production is low in comparison with the first group their exports take a stronger position.

The domestic demand in the United States has left little for export, even at the record rates of output in this country. The figures for the first half of 1923 show that the United Kingdom has shipped a tonnage equal to more than 50 per cent of its steel ingot production. French exports were in practically the same ratio for the first five months of the year, with nearly half the tonnage going into Belgium. The data that has been reported for Germany shows that for the first five months exports of iron and steel more or less balance imports. It is believed that a great deal of the iron and steel produced in Germany in 1922 and the first half of 1923 has gone into improvement and reconstruction of industrial works, including iron and steel plants. If this is the case Germany will be better prepared to take her place in the steel export field when conditions adjust themselves.

IRON AND STEEL EXPORTS FROM UNITED KINGDOM AND UNITED STATES, DURING FIRST TWO QUARTERS OF 1923

Gross Tons

Countries of Destination	From United Kingdom First quarter	From United Kingdom Second quarter	From United Staets First quarter	From United Staets Second quarter
United Kingdom	......	......	15,711	17,234
United States	143,659	88.359	.....	.....
Canada	18,634	34.021	184,301	221.803
Belgium	36,326	43.686	1,846	2,561
Denmark	13.734	14.831	*	*
France	30 534	43,439	2,557	2,859
Germany	40.507	86,816	*	*
Italy	26.686	24,345	622	1,784
Netherlands	20,651	19.303	1,038	1,282
Norway	9,900	12.261	678	1,290
Portugal	5,295	10.438	*	*
Spain	8,891	9.773	2,711	1,875
Sweden	7,366	10.491	*	*
Switzerland	1,071	3,745	*	*
Australia	130,395	121,647	12.880	8,476
China	11.403	12,020	9,367	13.421
Hongkong	4,550	3.863	3,198	3.975
India and Ceylon	177,976	153,041	9.195	1,753
Japan	46,683	81,628	50,088	91.648
Kwantung	......	......	1,281	10,785
New Zealand	32,007	23,701	1,399	1,170
Philippine Islands	......	......	6,815	7,935
Straits Settlements	10,333	10,246	*	*
British East and West Africa	7,989	24.966	*	*
British South Africa	36.022	40.316	2.280	5,165
Egypt and Palestine	9,181	22.126	*	*
Portuguese East Africa	5.182	5,004	*	*
Argentina	39.926	42,975	12.209	18,472
Brazil	8.955	6,243	9,552	10.439
Chile	4,475	6,584	8.346	8,273
Columbia	†	†	8,471	6.585
Cuba	†	†	27,302	52 855
Dominican Republic	†	†	1,455	2.812
Guatamala	†	†	1,187	1.762
Honduras	†	†	6.990	2,263
Mexico	†	†	18,949	23.268
Panama	†	†	1,522	2.467
Peru	†	†	6.141	6,538
Uruguay	†	†	1,704	2.396
Venezuela	†	†	2,412	2,628
Other South American countries	6,838	8,793	*	*
All other countries and nonallocated	* 143.860	211,953	13,043	18,120
Total	1,039.029	1,176.614	425,250	556,894

*Included in "all other countries."

†Included in "other South American countries."

According to the preceding table it is evident that the iron and steel trade of the United Kingdom for the first half of 1923 was more widely distributed and more evenly divided among the hemispherical groups of countries of the world. In this period practically five-eights of the total American export tonnage of iron and steel products went into Canada, Cuba. Mexico, and Japan.

It should also be noted that the figures for "all other countries" under the United Kingdom include a large tonnage which has not as yet been allocated. That part not distributed in the first quarter amounts to approximately 114,200 tons and in the second quarter to 158,000 tons. Where detailed figures for various countries are not given under the exports from the United States it may be understood that the total for the period would be less than 1.000 tons.

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The following is a brief summary of some of the principal articles published in Iron Trade Review from August 30 to date:

August 30

Prices of iron and steel remain practically unchanged, the composit of 14 leading products being $44.84 for the third consecutive week. Sales of pig iron continue in moderate buying. Sales of steel products reflect some improvement; prices are unchanged and in some instances premiums are paid for prompt delivery. A Luxenburg producer offered a Pennsylvania pipe maker 5,000 to 10,000 tons of No. 3 foundry iron at the equivalent of $21.80 f.o.b.

The three-shift plan is being adopted in many of the larger plants and it is estimated at this time that at least 25,000 men already have been effected by the change in the Pittsburgh district.

The business trend section shows that commodity prices are firmer, and that a change in trade sentiment is reflected in beginning of buying for the autumn.

The making of iron from ore by new electrotytic process at the plant of the Milford Electrotytic Iron Company, Milford, Conn., is described by E. C. Kreutzberg, Associate Editor at New York of Iron Trade Review.

An authoritative chronology of the Midvale Steel Company gives much historical data of interest to the iron and steel trade regarding the development of the industry in which Midvale was long an important factor.

Construction of a 12,000 ton hydraulic press for locomotive boiler work, by the Birdsboro Steel Foundry & Machine Company is illustrated and described.

The United States Navy's plans for scrapping war ships are given in this issue.

Statistics showing a decrease in iron and steel exports and imports are given. Iron and steel payrolls are lower.

September 6

Statistics show considerable falling off in coke pig iron production to a total of 3,442,614 tons compared with 3,684,67 tons in July, a loss of 242,063 tons or 7.03 per cent.

After a tour embracing the mining districts of Ontario and Quebec, the American Institute of Mining Metallurgical Engineers holds the technical sessions of its annual convention in Montreal. Brief abstracts of the papers are given in this issue.

The business trend section shows the influence of a more cheerful tone in many of the markets, buyers being confident and signs pointing to fall recovery.

The European war and its consequences has brought important consolidations of German iron and steel interests, less than a dozen great groups controlling iron and steel manufacturing companies and proportions of related industries.

China is described as a great potential market for American steel scrap; the opportunities are set forth in some detail.

A new classification card of extras on bar iron was issued, representing the first change to be made in the bar iron list since December 3, 1895. The general character of the new card is in advances although in some sizes the extras have been lowered.

September 13

Japanese buying is under way to considerable extent for reconstruction material. Chicago district mills received inquiries for 60,000 tons. Some improvement is noted in the steel market, rail orders are heavy and slight raise is noted in the composit of 14 leading iron and steel products. The composit is $44.72 this week, the raise due to slight increases in pig iron.

The daily rate of steel ingot output in August is 136,272 compared with 140,507 tons in July. The total ingot production in August was 2,797,962 tons as compared with 2,658,449 tons in July. The total for the month being largely because of two more operating days.

The wages of the 10-hour men in the steel corporation's mills are raised 10 per cent, marking the final wage adjustment necessitated by the change to the short day.

Germany abandons her method of quoting in marks and names iron and steel prices on the pound sterling basis, the equivalent comparing closely with quotations of American producers, and in some lines being higher.

Information is given concerning the effect of the earthquake on the Japanese iron and steel industry and how some American interests are effected.

An article in this issue describes the experiences that Northern industrial plants are having with negro labor imported from the southern cotton fields.

September 20

The iron and steel markets generally are quiet, and it is noted that easier deliveries are causing the Pennsylvania railroad and some other consumers to hold back tonnages. The leading transaction in the pig iron market was the purchase of 25,000 tons of Alabama foundry iron from a leading Southern producer, by the U. S. Cast Pipe and Foundry Company. The price composit this week is $44.70 against $44.72 for the week preceding. It is reported from Vienna that 5600 railway cars of an order for 14,000 for Poland are going to American builders.

Japan places an order for 4,000 tons of galvanized sheets in the British market.

The International meeting of foundrymen in Paris is described in some detail.

Iron Trade Review's business trend section indicates good fall trade, advancing commodity prices, and good buying power pointing to help in trade. An article from the European staff describing the seizure of German coke plants by Franco-Belgian authorities in this issue.

E. T. Weir, president of the Weirton Steel Company, contributed an article on "What the Steel Industry Most Needs" included are:

A better understanding of its problems and necessities by the public, a more liberal policy of publicity on matters affecting public opinion and rendering of constructive service by American Iron and Steel Institute.

A new 20-inch unit has been added to the Atlas Steel Corporation plant at Dunkirk, N. Y.

TRADE NOTES

The Uehling Instrument Company of Paterson, N. J., report considerable demand for their CO_2 recording and indicating equipment among central stations and pumping stations, the following orders having been received very recently: Cleveland Water Works, 6 units; North Point Pumping Station, Milwaukee, 4 units; Lake View Pumping Station, Chicago, 3 units; City of Wyandotte, Mich., Water Works, 4 units; Queensborough Gas & Electric Company, New York City, 4 units; Metropolitan Edison Company, Reading, Pa., 2 units; Philadelphia Electric Company, 6 units. The Philadelphia Electric Company purchased their first Uehling equipment in 1917 and will have 23 units, including the above order.

The Carnegie Steel Company has purchased for their Mingo Junction plant two Westinghouse "SK" motors complete with rails, two drum controllers with grid resistance and two Morse chain and sprockets complete for stoker drive. The motors are totally enclosed.

The power plant for the U. S. Navy Yard at Portsmouth, N. H., will be equipped with two Westinghouse new model multiple retort underfeed stokers specified by Mr. W. G. Cornell, contracting engineer. The stokers will be driven by Westinghouse steam engines and equipped with line shafting, regulators, balanced valves and Diamond chain drives. Two new 1,000-hp. Heine boilers have been purchased and the plant will use eastern bituminous coal.

The eight Westinghouse new model multiple retort underfeed stokers recently purchased by the West Penn Power Company for their Springdale, Pa., plant will be driven by eight two-speed, three-phase motors complete with slide rails and controllers. Sixteen three-phase squirrel cage rotor motors have also been ordered to drive the rolls on the rotary ash discharge devices. These motors are actually capable of developing two maximum and two minimum speeds, thereby giving a 4 to 1 speed ratio through two sets of poles, the stoker motors having six and twelve poles respectively and the grinder motors having six and eighteen poles respectively.

The Homestead Valve Manufacturing Company, manufacturers of the Homestead quarter-turn valve, announce that a consolidation has been effected with the Protected Seat Valve Company of the Peoples Bank Bldg., Pittsburgh, Pa. The Protected Seat Valve Company has been manufacturing the B & O protected seat globe valve and the protected seat hydraulic operating valve, also a full line of check valves and angle valves with the protected seat feature. This line will now be made at the plant of the Homestead Valve Manufacturing Company and marketed along wtih the other products of the Homestead company. The patented seat, which is the distinctive feature of this line of valves, prevents wear and cutting out of seating surfaces by fluids when passing through the valve, and results in freedom from leakage for long periods of time. The complete line is now being developed and the Homestead Company expects to be ready to supply users within the next six months. In the meantime a limited number of sizes are either in stock or can be supplied on short notice. The hydraulic operating valve, used for controlling hydraulically operated machinery, can be used for long periods without constant changing of leather cups, these being unnecessary with this form of construction. Threeway operating valves are being used in several plants, and the company is in position to book orders for prompt delivery. These valves will be known as the "Homestead Protected Seat Globe Valve" and the "Homestead Protected Seat Operating Valve." The full line will be developed and the Homestead Company expects to have it ready to place on the market within the next six months. At the present time a number of the sizes can be supplied.

Dempsey Furnace Company, 15 Park Row, New York City, has acquired factory premises at 61-63 Cornelison Avenue, Jersey City, N. J., where they will manufacture industrial oil burning equipment, as well as the furnaces associated with their name.

F. J. Ryan & Company announce recently closed contracts: Standard Steel & Bearings Company, Plainville, Conn., 3 double chamber car type annealing furnaces for ball races; Rickenbacker Motor Car Company, Detroit, Mich. (closed by Mr. D. P. Harr of the Detroit office), 2 pot and 1 oil tempering furnace, 1 annealing furnace, 3 carbonizing furnaces; Pusey & Jones Company, Wilmington, Del., equipment for oil firing of boilers, including "Ryan-Austin" automatic control; U. S. Cast Iron Pipe & Foundry Company, Birmingham, Ala., "Ryan-Austin" automatic control for pipe annealing furnace; Wilmington Furniture Company, Wilmington, Del., equipment for oil firing of boiler; Hupp Motor Car Corporation, Detroit, Mich., automatic pyrometer control equipment for new heat treating plant at Jackson, Mich.; Penn Seaboard Steel Company, Tacony, Pa., burner equipment for entire battery of core ovens; Reading Hardware Company, Reading, Pa., 10 brass melting furnaces.

A new leaflet illustrates and describes the Hays automatic CO_2 and draft recorder, Model B. It combines new, exclusive features with the recognized accuracy and reliability of previous Hays recording instruments. The principle of operation has been simplified; a greatly improved appearance will be noted, and also greater ruggedness and accessibility of parts. The steel caustic tank holds a four months' supply so only three renewals per year are required. An accuracy of one-half of 1 per cent CO_2 is guaranteed.

COMING MEETINGS

October 1-6—National Safety Council convention and exhibition, Hotel Statler, Buffalo. W. H. Cameron, 168 North Michigan Avenue, Chicago, is secretary.

October 2-4—National Machine Tool Builders' Association annual convention at Lenox, Mass. E. F. du Brul, 813 Provident Bank Bldg., Cincinnati, is secretary.

October 2-5—American Institute of Electrical Engineers Pacific coast convention, Del Monte, Cal.

October 8-12—American Society for Steel Treating annual convention at Pittsburgh. W. H. Eisenman, 4600 Prospect Avenue, Cleveland, is secretary.

October 8-13—National Fire Protection Association. International Fire Prevention Congress, Seventy-first Regiment Armory, New York. The secretary of the association may be addressed at 25 East Twenty-sixth Street, New York.

October 15-20—American Gas Association annual convention, steel pier, Atlantic City, N. J.

October 23-24—American Society of Mechanical Engineers regional meeting, Chattanooga, Tenn. E. C. Patterson, general manager, Chattanooga Boiler & Tank Company, Chattanooga, Tenn., is in charge of details.

October 24-26—National Association of Farm Equipment Manufacturers annual meeting at Cleveland.

October 24-26—American Welding Society fall meeting at Pittsburgh. M. M. Kelley, 33 West Thirty-ninth Street, New York.

October 25—American Iron and Steel Institute fall meeting, Hotel Commodore, New York. E. A. S. Clarke, 40 Rector Street, New York, is secretary.

October 25-27—American Gear Manufacturers Association fall meeting, Mountain House, Lake Mohonk, N. Y. T. W. Owen, 2443 Prospect Avenue, Cleveland, is secretary.

October 29-31—American Management Association meeting at Hotel Astor, New York.

The Open Hearth

A. A. Corey, Jr., has been elected president of the Vanadium Corporation of America. Mr. Corey's broad experience and association with heavy producers of alloy steels should ideally fit him for this new responsibility. His years of service as general superintendent of Homestead Steel were characterized by constant action; the building of the famous Liberty 110-in. plate mill (motor driven) in 85 days by labor largely recruited from volunteers will ever stand as an achievement signal even in war-time records. He is remembered as the man who got things done. The reorganization of Midvale, of which he was vice president, and president of Cambria, and its absorption by Bethlehem creates this opportunity for him. No executive carries with him a greater host of well wishers.

The Imperial Brass Manufacturing Company, Chicago, manufacturer of brass specialties and oxy-acetylene welding and cutting equipment, and automatic acetylene generators, has opened a branch office in the House Building, Pittsburgh, under the management of John A. Coyle, who for 25 years was actively connected with the high grade steel making industry, with the Crucible Steel Company of America, the Baldwin Steel Company, the Hess Steel Castings Company, the National Drawn Steel Company, and recently, with the Universal Steel Company. Associated with Mr. Coyle will be Elmer H. Miche, one of their factory experts who will specialize on oxy-acetylene welding and cutting apparatus. The Pittsburgh office is prepared to render rapid service making repairs.

Mr. Russell R. Shepard, who has been identified with the Steel & Tube Company of America since 1916, formerly electrical superintendent and more recently as electrical supervisor, has severed his connection since the merger with the Youngstown Sheet & Tube Company. Mr. Shepard has not yet determined his further course.

W. F. Singer, formerly with the American Sheet & Tube Company and during the past 10 years manager of the Winton Steel Company's tin mill at Steubenville, Ohio, has tendered his resignation and intends taking a much needed rest.

The Vulcan Mold & Iron Company has built a new ingot mold foundry at Latrobe, Pa. Operation was started three months ago and they are now producing about 50 tons daily. They are specializing in high grade split sizes and shapes, and through the purchase of the entire mold business of the Blairsville Iron Works have on hand patterns and equipment for the manufacture of most sizes used by the various tool steel companies in the country. They also specialize in small solid molds and particularly those of intricate shape, such as corrugated and fluted molds and those of the Gathmann type. The plant, which occupies five acres of land, consists of the main foundry, 183x300 ft., in which all molding is done by molding machines, and one building 70x90 ft. Auxiliary buildings include machine and pattern shops. Quality of product has been the most prominent feature in the establishment of this business and such molds as have been furnished the trade in the last three months have proved to give excellent satisfaction both as to finish and life. The authorized capital stock of the company is $500,000, which is nearly all owned in Latrobe. The board of directors and officers are as follows: D. T. Sipe, chairman of board of directors; C. M. Semler, M. W. Saxman, J. E. Barnett, F. B. McFeely, H. H. Smith; E. H. Williams, president.

A recently issued circular describes a special class of industrial service of practical value to concerns interested in improved methods of handling their raw materials and finished products, as well as goods in process of manufacture. The Material Handling Advisory Bureau is the only organization of its kind in the country and aims, (1) to provide an advisory and technical consultation service at a moderate service charge, and (2) to promote the more extensive use of mechanical handling equipment of all kinds, through a systematic campaign of education. To the manufacturer, this service can be made of value through the recommendation of his type of equipment where it meets the requirements of the work under consideration. Mr. Harwood Frost, director of the bureau, 10 South LaSalle Street, Chicago, is well known in this field, having had many years of active experience in the design, manufacture and application of various types of material handling equipment, and in the study of handling methods. He has made many addresses and contributed largely to periodicals on various phases of the subject.

"Lopulco Pulverized Fuel Systems" is the title of a new catalog offered by the Combustion Engineering Corporation. This is the first publication they have issued that describes both the theory and mechanical features of their powdered coal system which, within the past year, has been installed in connection with some of the most notable boiler plant projects in the country. The catalog is

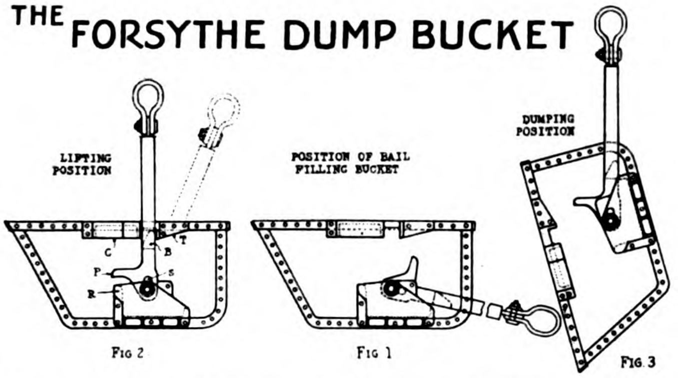
(Concluded on page 563)

WITH THE EQUIPMENT MANUFACTURERS

Improved Dump Bucket

The Forsythe patented dump bucket should fulfill a long needed improvement in the operation of a manually loaded dump bucket. It eliminated the necessity of a man following the bucket to the place where it is to be dumped, or a man stationed at the dumping location, as the crane operator can dump the bucket from his position on the crane without any assistance.

It not only saves one man's time, but also avoids accidents, which are frequent, to the man who dumps a bucket which must be unlatched by him.



This bucket has proven its value in steel plants for the past two years, where labor and accidents have been eliminated.

Fig. 1 shows the bucket with the bail down in position for loading.

Fig. 2 shows the bucket in position of being lifted. This is accomplished by moving the crane so that the bail will go up against the stop, "C." Then the bail may be raised, which causes the block "B" to go up into the slot between the stop "C" and the tipper cam "T," which will prevent the bucket from tipping. The bucket can then be carried to any place for dumping. Note the slotted opening in the bail ends marked "S." The bail is attached to the bucket by heavy trunions.

Fig. 3 shows the bucket in position of dumping. In order for the crane operator to dump the bucket, he merely lowers it to the place of dumping, then slackens the cable to allow bail to lower in slot. The bail is then tilted into the position shown in dotted lines, Fig. 2, by the projection P or the bail coming in contact with a stop just beneath the tripper projection. The operator then moves the crane slightly and pulls upward, which permits the bucket to dump its load. Note that the load merely spills out of the bucket, avoiding the impact usually caused by dropping the load, avoiding injury to equipment into which the material is being dumped, and avoiding dust, etc.

A level place is not required for dumping, as it will operate from most any inclination or position.

This bucket is not an experiment as it has been in service for two years in steel mills, handling roll scale, spiegel, hot cinder, hot crop ends from shears and saws, concrete, sand, gravel, dirt, coal, brick, etc.

This bucket was patented by J. W. Forsythe and is being put on the market by Jno. D. Hiles Company, Oliver Bldg., Pittsburgh, Pa.

Progress in Steel Castings Industry

Delivering commercial steel castings to the customer from furnace charge to sand-blast finished product in a city exhibition building is something new.

It upsets all preconceived ideas of foundry operating conditions and illustrates most forcibly the very recent progress made in this industry. Continuous heats of commercial steel castings poured daily were cleaned with Pangborn dustless sand-blast equipment at the Iron and Steel Exposition held at Buffalo September 24-28.

You can have your foundry cleaning room or industrial sand-blasting as free from dust and dirt as in this exhibition building.

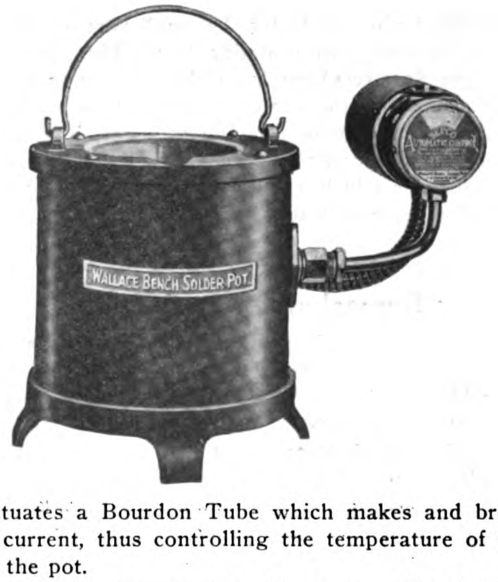
Every last phase of electrical development to the iron, steel and allied industries was shown here as well as the modern way of Pangborn dustless sand-blasting, with comfort and convenience for the operator, that produces better work and more of it.

Solder Pot That Saves Material and Time

A new electric solder pot with automatic heat control has been added to the line of labor saving devices manufactured by J. D. Wallace & Company, Chicago. It greatly simplifies the problem of heating babbit, white metal, wax and other materials which are slow conductors of heat.

Solder must be kept at a uniform temperature if satisfactory results are to be obtained. When metal is overheated it oxidizes, and this action results in a considerable loss of material and tensile strength. The Wallace solder pot is designed to overcome this oxidation. When solder has been heated to 600 deg. F. an automatic control goes into action. This control maintains the temperature of the contents of the pot and prevents overheating and underheating.

This control is an adaptation of the principle used in the steam gauge. A volatile substance, which is very sensitive to heat, actuates a Bourdon Tube which makes and breaks the electric current, thus controlling the temperature of the contents of the pot.



The pot will accommodate 15 pounds of solder and will heat this amount to 600 deg. F. in 20 to 25 minutes. This quick action is due to the fact that a 900-watt heating element is built around the entire container. Heat is applied to all parts of the sides and bottom of the container simultaneously, thus coming in contact with the solder at all points, and reducing it to a working consistency.

In addition to maintaining the temperature of the solder at the proper temperature, thus insuring full strength and uniform workmanship, the Wallace electric solder pot is a great conserver of time and effort.

The pot weighs only 13 pounds, can be easily carried anywhere, and operates on either 110 or 220-volt alternating or direct current. Workmen need not waste steps going back and forth between their work and a heater.

Although only recently placed on the market, this new solder pot is already enjoying healthy sales. Full particulars may be had from J. D. Wallace & Company, 1401-17 West Jackson Boulevard, Chicago, Ill.

Gas Conditioning for CO_2 Recorders

Soot, moisture and sulphur are the three natural enemies of the CO_2 recorder. New Bulletin 116A of the Uehling Instrument Company, 473 Getty Avenue, Paterson, N. J., illustrates three simple devices which, it is claimed, completely eliminate these three troublesome elements. In other words, they permanently prevent fouling and corrosion of the CO_2 equipment and the tubing which conveys the gas sample to the instrument continuously. These three devices are known as the "Pyro-Porus" filter, the gas drier and the gas purifier.

The "Pyro-Porus" filter is placed in the direct path of the hot flue gases, on the extreme end of the gas sampling line. The actual filtering is accomplished by two highly porus refractory discs. These discs remain in continuous service for many months at a time without requiring replacement and without offering increased resistance to the gas flow.

The gas dryer completely removes moisture from the gas, thus preventing pockets of water collecting at low points of the line, interfering with gas flow. By drying the gas, the life of the material used for absorbing the CO_2 is also considerably prolonged.

The purifier is a brand new development. It is claimed that it completely removes sulphuric acid fog which has heretofore been one of the most elusive and harmful properties in flue gas. By eliminating water vapor and sulphuric acid, corrosion is impossible.

The bulletin also illustrates the small bore seamless drawn tubing used for the gas sampling line. This gives high velocity of gas flow resulting in quick response to the CO_2 recorder to changes in furnace conditions. This tubing is much easier to erect than pipe, which was formerly employed for the purpose, and practically eliminates all possibility of sampling line leakage which is a common failing of sampling lines constructed of pipe instead of tubing.

Remarkable Metal Finish

After many years of experimentation, chemists have now developed a new finish for wood and metal, which it is claimed is so durable, tough and hard that it will resist high degrees of heat, hot or cold liquids and hot plates or dishes. It is described also as absolutely waterproof—in fact, it can be washed with soap and water.

The new material, which is known as viscolac, is now in use in many wood and metal working industries including the manufacture of automobiles and furniture. It is made of ingredients entirely different from those of the old style varnishes. It is a pyroxylin solution, which is developed from cotton and which seems to have a natural affinity for wood and metal surfaces of all kinds.

It has been tested out under some of the most difficult conditions, even live steam having been turned on it and yet it was found to survive this test. Chemists state that it does not readily chip or crack, is unusually hard and tough and has the extraordinary advantage from a manufacturing standpoint that it air-drys very rapidly.

The chemists who produce viscolac believe that it will completely revolutionize the art of wood and metal finishing. They point to the fact that tables and other household furniture finished with this new material are completely immune from any harmful effects of food or any kind of liquids being spilled on them.

Automobiles finished with the viscolac type of enamel retain their original beauty much longer than the ordinary finishes.

Stoker Manufacturers' Association

The stoker manufacturers included in the membership of the Stoker Manufacturers Association have been farsighted enough to know that in their business conscientious engineering counsel covering the requirements of individual installations is just as important as quality of product. In fact, complete engineering service is more important when it is considered that the best mechanical stoker will fail if it is not properly adapted to local conditions and coals.

The study made by the engineering departments of these well established stoker manufacturers covers the analysis of coal of different localities, firing rates necessary for different plant loads, methods of coal feed and ash disposal, and innumerable other factors. Some of these may be only indirectly related to the stoking equipment, but upon them the success of the stoker often depends.

Since the present high standing of the mechanical stoker industry, as well as its future growth, depends upon the ethical standards of the engineering organizations which comprise it, it is natural that the stoker manufacturers should seek the means of guarding the standards of the industry and fostering still greater engineering development. This is the purpose of the Stoker Manufacturers Association.

With the future of stoker firing in mind, the members of the S. M. A. have all pledged themselves to truth in advertising, square dealing, and scrupulous fulfillment of every contract.

The Stoker Manufacturers Association, G. A. Sacchi, secretary, Lester Branch, Philadelphia, Pa. American Engineering Company, Philadelphia, Pa.; The Babcock & Wilcox Company, 85 Liberty Street, New York, N. Y.; The Burke Furnace Company, Chicago, Ill.; B. F. Sturtevant Company, Hyde Park, Boston, Mass.; Combustion Engineering Corporation, 43 Broad Street, New York; Detroit Stoker Company, Detroit, Mich.; United Foundry & Machine Company, Canton, Ohio; Laclede-Christy Company, St. Louis, Mo.; Sanford Riley Stoker Company, Worcester, Mass.; Westinghouse Electric & Mfg. Company, Lester Branch, Philadelphia, Pa.; Illinois Stoker Company, Alton, Ill.

The Reliance Electric & Engineering Company of Cleveland, Ohio, have just issued and are distributing to interested parties a 51-page reprint of the excellent paper by A. M. MacCutcheon, chief engineer of the company, which was presented at the Buffalo convention of the Association of Iron and Steel Electrical Engineers.

The discussion is a general one, covering all phases of the controversy between various anti-friction metals in bearings and oil-ring types of bearings.

The pamphlet is profusely illustrated and includes the complete discussion by well-known electrical engineers which followed the presentation of the paper by Mr. MacCutcheon.

Some Pointers on By-Product Coke Oven Operations

The Weirton Steel Company, Weirton, W. Va., has work nearing completion on its new sheet mills and plans to place the units in service during August. They will provide for extensive increase in output and it is purposed to develop maximum capacity at an early date. A new battery of coke ovens, with by-products plant, has recently been placed in service. The new plant comprises 37 ovens, with carbonizing capacity of 1,000 tons per day. The output will be utilized at the Weirton and Steubenville mills of the company and will bring about marked economies as compared with the heretofore necessary and expensive haul from the company's coke plant at Brownsville, Pa. In connection with the new works, it is planned to produce a complete line of by-products.

The "fuel question" has become a serious issue in every industry and in every home. The high cost of fuel is felt by almost every citizen in the land. The supply of natural gas is failing rapidly, the price of artificial illuminating gas increases with the cost of the coal and oil from which it is made, and with the increased demand for oil the price of that fuel fluctuates and the supply is uncertain. In those states depending largely upon anthracite, much inconvenience, and even suffering, has resulted from the limited supply and consequent high prices. The greater part of the country is dependent upon bituminous coal, of which there is practically an unlimited quantity available for mining, but the cost of transportation and the interruptions in the mining industry have resulted in prices which, in many cases, have doubled in a few years. There is little relief in sight except that relief which will result from a more efficient use of the fuel available.

Smith suction gas producers have furnished the answer to many knotty fuel problems in American industry by making it possible to utilize the available fuel in a more economical way.

There are a great number of industries where steel, iron, glass, ceramic products and non-ferrous metals must be heated in an economical and dependable manner. Here, Smith gas finds its widest fields of application.

Industrial and public utility power plants have adopted the Smith gas producer and the producer gas engine as a means of developing power, because one ton of coal used in this way will generally develop from two to five times as much power as when used in other types of power plants. In some localities bad water conditions make the operation of steam plants difficult and expensive, or the fuel available may be undesirable as a boiler fuel, but very desirable as a fuel for Smith producers.

Smith gas producers have been largely adopted in the food baking industry where gaseous fuel is so desirable. It is particularly desirable in this industry because under no circumstances will Smith gas, when burning in an oven, produce a smoky flame. Taken the country over, this gas costs only about half the current prices of city gas. The same thing is true as to those industries having japanning and other baking operations where Smith gas has no equal in economy and general utility.

Statistics compiled by the Department of the Interior, through the Bureau of Mines, show that accidents at coke ovens throughout the United States during the calendar year 1922 resulted in the death of 29 men and the injury of 1,710 employes. Of the fatalities reported, 8 occurred at beehive coke ovens and 21 at by-product ovens. Injuries, involving a minimum of one day's disability, at beehive ovens amounted to 474, while the number reported from by-product ovens is 1,236.

The injury rate at both beehive and by-product ovens was lower in 1922 than in 1921. The fatality rate for beehive ovens was also reduced, but the rate for by-product ovens increased slightly.

At beehive ovens 98 men out of every 1,000 employed sustained injuries as compared with 119 the year before. The fatality rate at beehive ovens was 1.66, a reduction from the 1921 figure of 1.76. For by-product ovens the injury rate was reduced from 138 in the 1921 to 92 in 1922, while the fatality rate rose from 1.09 to 1.57. These rates are based upon a unit of 300,000 shifts, which is equivalent to 1,000 men working 300 days.

Reports to the Bureau of Mines from both beehive and by-product ovens showed a total of 19,278 men employed, each man averaging 284 days of work, the volume of work by all employes being 5,470,939 man-days. Comparing these figures with 1921, they indicate an increase of 19 per cent in the number of employes, an increase of 10 per cent in average work days per man, and 31 per cent in total number of shifts worked in the entire industry.

Most of the accidents occurring at beehive ovens were due to falls of persons, cars and motors, burns, falling objects, coke-drawing machines, hand tools, and nails and splinters.

At by-product ovens, 21 employes were killed and 1,236 injured, the principal causes of accidents being falls of persons, burns, falling objects, hand tools, cars and motors, nails and splinters, and coke-drawing machines, in the order stated.

The York, Pa., Gas Company has had to give considerable study of late to the matter of its increasing output of gas. After having a careful survey made of the manufacturing facilities, it was found that the present apparatus was inadequate to handle the expected load. In order that there may be no interruptions to its service, it has, therefore, contracted with the U. G. I. Contracting Company of Philadelphia for the installation of one 9-ft. cone top carburetted water gas apparatus, which will embody all the latest developments for this size apparatus.

In addition to the water gas apparatus, a U. G. I. tar extractor will be installed. This additional equipment will give the York Gas Company an increased manufacturing capacity in excess of 2,000,000 cu. ft. per day.

At various times the Public Service Gas Company has installed U. G. I. automatic controls in the various gas plants of its system, until it now has several automatic controls in regular operation.

The first of these controls was installed in the early part of 1920 and it has just placed its latest order with the U. G. I. Contracting Company of Philadelphia for another Model B automatic control to be installed at the Market Street Works, Newark, N. J.

The U. G. I. Contracting Company, Philadelphia, has received a contract to install a 6-ft. set of carburetted water gas apparatus at the plant of the St. Augustine, Fla., Gas Company.

PULVERIZED FUEL

(Continued from page 560)

printed on dull coated stock in duotone ink. It contains numerous illustrations, including a section through a Lopulco equipped boiler plant which shows all the different elements of the system, as well as interesting test data, and information concerning some of their outstanding installations.

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NEWS OF THE PLANTS

The Jones & Laughlin Steel Corporation, Pittsburgh, Pa., has acquired a large tract of land along the river front at Memphis, Tenn., as a site for a new branch plant for southern trade, preliminary plans for which are now under consideration. In addition to general operations it is purposed to equip the new works in part for steel fabricating and affiliated service. The plant as now projected will consist of a number of mill buildings, power house, and subsidiary structures.

The Day-Evans Iron Works, Inc., Knoxville, Tenn., is perfecting plans for the construction of a new local iron and steel plant and will soon break ground for the initial buildings. The main structure will be 75 x 150 feet, with adjoining smaller buildings, estimated to cost approximately $100,000, including equipment. A. W. Evans, Petros, Tenn., is one of the officials of the company, and will act as construction engineer for the project; purchases of machinery and equipment will be made under his direction. It is proposed to construct other plant structures in the near future.

The Acme Steel Goods Company, Riverdale, Ill., is completing the construction of a new addition to its plant, to be used as a cold rolled strip steel mill, and plans to place the unit in service at an early date, giving employment to a large increased working force. The new plant addition will represent an investment of close to $1,000,000, with machinery, and has been designed to advance the capacity of the works about one-third.

The Metal & Thermit Corporation, 120 Broadway, New York, N. Y., has work in progress on its proposed new rolling mill at South San Francisco, Cal., where a large tract of land on Swift Street has been laid out for the new works. It is proposed to install machinery at the earliest possible date and place the mill in service; it will be operated in conjunction with the other works of the company in this same district. The new plant is estimated to represent an expenditure of close to $2,000,000, with equipment.

The American Steel Band Company, Progress Street, Pittsburgh, Pa. has commenced the construction of a new mill on property recently acquired on Nixon Street, for which a general contract has been let to the Austin Company, Union Trust Building. The new mill will be one-story, 60 x 200 feet, and is estimated to cost about $30,000. The company has a large tract of land in the district noted and is said to be planning for the construction of additional buildings at a later date.

The Pacific Coast Steel Company, San Francisco, Cal., operating plants at South San Francisco, Linnton and Oswego, Ore., and Seattle and Youngstown, Wash., has tentative plans for the construction of a new blast furnace to be located at South San Francisco, or on waterfront site now under consideration at Long Beach, near Los Angeles. In connection with the latter location, it is proposed to build and operate a complete steel works for Southern California and southwestern trade, with rolling mills, power house and other structures, estimated to cost in excess of $5,000,000. It is said that a fund of approximately $15,000,000, is being arranged for expansion, including the Long Beach project noted, covering work at existing plants as well as the purchase of other existing properties and mills. The company has recently increased its capital and officials of the organization are interested in the Pacific Steel Corporation, recently organized under Delaware laws with a capital of $40,000,000, designed to take over and merge a number of properties in the coast district. These will include, it is reported, the Pacific Coast Steel Company, the Southern California Iron & Steel Company, and the coal properties of the Milner Corporation, located in Utah. E. H. Wilson is president of the present Pacific Coast Company.

The Wisconsin Steel Works, Torrence Avenue and 106th Street, Chicago, Ill., has awarded a general building contract to the A. Harrison Company, 8027 Muskegon Avenue, for the erection of a new addition to its plant for general expansion. It will be one-story, 40 x 130 feet, and estimated to cost approximately $35,000. H. S. Baetzman is company architect in charge.

The Mystic Iron Works, Everett, Mass., recently formed under state laws, is perfecting plans for the construction of a new blast furnace on site on the Mystic River, close to the present coke works of the New England Coal & Coke Company. The initial plant will be designed for a capacity of about 500 tons per day, and with auxiliary structures will cost in excess of $2,500,000, including equipment. Application has been made for permission to build the plant, and it is purposed to finish plans and commence work at an early date. It is estimated that it will require about 12 months to complete the furnace, which will be devoted to pig iron production. The plant will be the first of its kind in the New England district. Arrangements are being made for raw material supply, including limestone from extensive deposits in Maine. The new company is closely affiliated with the Massachusetts Gas Companies, Boston, Mass., and officials of that organization will head the corporation.

The West Leechburg Steel Company, West Leechburg, Pa., has completed the construction of its new additions, on which work has been in progress for some time past. The different units will be placed in service at once and when in full operation will give employment to an additional working force of close to 500 men. The new structures represent an investment of close to $2,000,000, and will provide for large increase in former output. It is expected to develop maximum output at the mills at an early date.

The Dodge Steel Company, State Road and Hellerman Streets, Philadelphia, Pa., has work in progress on a new addition to its plant and expects to have the structure ready for service at an early date. It will cost about $30,000, and will provide for considerable increase in output. The general contract for the building was awarded recently to the Austin Company, Bulletin Building, Philadelphia.

The American Puddled Iron Company, Youngstown, Ohio, recently organized, is perfecting plans for the early operation of its new mechanical puddling plant at Warren, Ohio, and it is expected to develop full output within the next 30 to 60 days. The plant comprises the former Warren works of the Youngstown Steel Company, and has been remodeled and improved for the new production. The company is operating with a capital of $3,500,000, and plans for extensive activities throughout the Youngstown district. E. L. Ford is head.

The Ashtabula Sheet Steel Company, recently organized by Mansfield, Ohio, interests connected with the Mansfield Sheet & Tin Plate Company, has acquired the local plant and business of the Ashtabula Steel Company, formed a few years ago. The new company will take immediate possession and purposes to expand the plant, which consists of eight hot mills and two cold mills, and subsidiary structures. It is proposed to rebuild one of the present mills and equip as a jobbing plant. An appropriation of close to $300,000 has been arranged for. The new company is headed by W. H., A. L., and Samuel Davey, all of Mansfield.

OCT 17 192

National Enameling and Stamping Continued in November

The Blast Furnace and Steel Plant

Member of the Audit Bureau of Circulations

PITTSBURGH, PA., OCTOBER, 1923

Entered as second class mail matter at Pittsburgh, Pa., under the Act of Congress, March 3, 1879.

G-E

Shoe Type Solenoid Brakes

For Direct-current Motors

This CR9511 new spring-set brake fully meets actual service requirements of crane and auxiliary motors in steel mills —it gives the utmost service.

All parts are simple, durable, and accessible. Bearings, pins, shoes, and other wearing parts are very liberal in size. The moving parts have short distances of travel, which reduces shocks in setting and releasing to a minimum. Only three adjustments are necessary—and are simply made by means of nuts located at the top of the brake in plain view, and accessible from all sides.

General Electric Company
Schenectady, N. Y.

GENERAL ELECTRIC